

PRINCIPLES AND PRACTICE
of
**Implant
Dentistry**

CHARLES M. WEISS ■ ADAM WEISS

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of
**Implant
Dentistry**

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Foreword

Congratulations on your decision to read this book. Although implant dentistry has been a part of the dental profession for many years, information on the subject that is both easily understood and pragmatic has been difficult to find. This book provides you with information that is simple and can be easily implemented into your practice.

Implants have been a part of my prosthodontic practice for most of my 40 years in the profession, and the surgical aspects of implant dentistry have become a major part of my practice over the past 15 years. Now, it is discouraging to remember the dentistry of the relatively recent past, when the additional support for prosthodontics afforded by dental implants was not available.

Implant dentistry is a very dynamic and therefore exciting area of dentistry. Techniques, materials, devices, and clinical and research knowledge about the subject change daily. Staying fully informed about the most recent developments in implant dentistry is wise, but with the subject matter expanding so rapidly this endeavor can become all-consuming. To fully understand and appreciate the latest cutting-edge developments in the field, and the implications of the changes that take place every day, one must first have a firm grasp of the underlying surgical, biomechanical, and physiologic principles of mainstream treatment.

To that end, this book is an excellent contribution to your fundamental knowledge of implant dentistry. Most restorative- and prosthodontics-oriented practitioners be-

gin by learning the prosthodontic aspects of implant dentistry, and some, but not all, continue to become educated about the surgical aspects. Periodontists and oral surgeons, on the other hand, usually learn the surgical aspects only, and relatively few learn the fundamentals of the prosthodontic phase, which in fact is the point of implant insertion—to provide support for restorative dentistry. It is certainly beneficial to practitioners involved with either aspect of implant dentistry to gain a practical understanding of the entire process, from diagnosis through restoration through home care, to better serve their patients. This book provides invaluable step-by-step information about the comprehensive implant dentistry process, from recognizing safe and predictable cases, to differential diagnosis among the various implant systems and modalities, to surgical insertion, to prosthodontic restoration, to aftercare.

Principles and Practice of Implant Dentistry is a great educational resource for students and practitioners at all levels of implant dentistry knowledge, from the true beginner to the seasoned veteran. The easily understood step-by-step mainstream procedures are well illustrated and provide essential guidance. No aspect of the field is left uncovered.

I know you will enjoy increasing your knowledge and improving your clinical skills in implant dentistry.

GORDON J. CHRISTENSEN, DDS, MSD, PhD, ScD
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Foreword

I am most honored to provide a foreword for *Principles and Practice of Implant Dentistry*. My comments are separated into sections: a historical perspective and evolution of the discipline of implant dentistry, an overview of the book itself, and some aspects of interactions I have had with the authors.

HISTORICAL PERSPECTIVE AND EVOLUTION OF IMPLANT DENTISTRY

Dental practitioners realize that new laboratory methods and chairside techniques have been introduced by individuals with interests central to improving clinical treatments and outcomes. These new methods and techniques have come from basic research and applications, often conducted by practicing clinicians.

Dental schools have always included coursework on the uses of surgical and restorative materials and associated procedures, including the extended applications of synthetic biomaterials for surgical implant devices, as a formal part of professional and specialty training. From the outset, therefore, implant dentistry evolved as a multidisciplinary activity. Most important, the literature associated with this process over the past decades has documented an ever-improving and expanding success for functional prostheses based on surgical implant reconstructions of partially and fully edentulous patients.

My involvement with biomaterials research, which started in the 1960s, led to interactions with a number of expert dental implant practitioners plus specialists from dentistry, medicine, and engineering. Interactions also existed with talented and knowledgeable laboratory-, industry-, and affiliated discipline-based individuals. One of the first series of lectures that I attended that was specific to implant dentistry was given by Charles M. Weiss, DDS. Many of the positions and concepts presented in that first lecture in 1970 have withstood the test of time and have been woven into the fabric of this clinically oriented, evidence-based “mainstream” book.

OVERVIEW

This book is divided into five sections with a total of 23 chapters whose main theme is clinical implant dentistry and its underlying science. The book provides in-depth descriptions of the step-by-step procedures for mainstream treatment, including criteria for patient selection and

treatment planning, surgical and restorative rationales and methods, longer-term maintenance and care, and professional office and practice management. Each of the teaching sequences is referenced to published literature and strongly supported by diagrams, schematics, radiographs, and color photographs. Section Two, which discusses the related research, provides an unusually broad-based review of the relevant literature, including investigations in which Dr. Weiss participated. This section is also supported by graphics, radiographs, and photographs ranging from precise intraoral views to detailed histologic and electron microscopy images. The overall collection of information in this book represents an extremely valuable record supporting a multimodal approach to implant dentistry.

THE AUTHORS

Dr. Weiss has been continuously involved with the multiple aspects of implant dentistry through decades of participation at local, national, and international meetings. In this regard, the information and references in this book provide a broad and extensive testimony to the scope and breadth of his involvement. While maintaining a central position, Dr. Weiss has always welcomed an exchange of opinions; been willing to provide written and referenced documentation of ideas, concepts, and results; and been eager to debate and actively define his positions. This book reflects many of those experiences and follows a central concept of promoting a multimodal approach to mainstream oral rehabilitation partially or totally supported by dental implants with evidence-based validity.

I also congratulate Adam Weiss, son of Dr. Weiss, and co-author of this book, for synthesizing multiple sources of information with outstanding clarity while maintaining a balance to facilitate readers’ assimilation of the material. His grasp of organization and logical flow of information substantially enhances the value of this book.

The authors make two important points specific to the practice of implant dentistry—that professional treatment and satisfaction of the patient is one of the most critical issues, and that collectively, the use of multiple implant modalities and techniques provides the broadest base of options, which in turn expands the longitudinal scope of patient treatment. The rationale for this approach is supported and reinforced by a significant number of other dentists whose primary practice is the surgical placement and prosthodontic restoration of dental implants. Collec-

tively, this group represents a significant asset—a sizable pool of invaluable, long-term experience. The book includes detailed discussions on the basic developmental background, shorter-term experiences during clinical trials, longer-term experiences specific to restorative techniques, and summary outcomes from consensus conferences presented at professional meetings. Overall, a balance is provided by including information and options on multiple modalities, with significant and substantial content on currently popular root form systems.

A most important aspect of this book is that it assembles, documents, and presents Dr. Weiss' lifetime of involvement in implant dentistry as a clinician, inventor, researcher, and supplier of a wide variety of implant systems. This lifetime involvement has focused on the use of surgical implants to provide abutments for early support and functional intraoral prostheses for partially or totally eden-

tulous individuals. Writing this book represents a significant commitment of time, energy, and resources, for which the authors, their associates, and their families are to be congratulated.

I recommend *Principles and Practice of Implant Dentistry* to students at every level, as well as to established dental practitioners, as an in-depth, basic guide to multimodal techniques, and as a resource of important concepts and related technical and scientific information within the discipline of implant dentistry.

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Preface

GOAL OF THE BOOK

Our purpose in writing *Principles and Practice of Implant Dentistry* is to bring implant dentistry to everyone in the profession who can and should be involved in the insertion phase, the restoration phase, or both. The book is for undergraduate, graduate, postgraduate, and continuing education students, as well as for practitioners who are students of implant dentistry in the broader sense, who wish to deepen their knowledge and expand their scope of treatment. Whereas most implant dentistry literature tends to focus on complex cases, this book meets the need for instruction that focuses on the safe and predictable cases that compose the majority of what the typical implant practitioner encounters in practice.

There are several keys to becoming involved with implant dentistry. First is being able to recognize mainstream cases, defined in this book as those that can be treated safely and predictably. Second is knowledge that several implant modalities and systems have been proven safe and effective for the treatment of mainstream cases. Third is learning how to treat such cases step by step, from diagnosis through final restoration. *Principles and Practice of Implant Dentistry* provides you with these keys. As in all areas of study, first we walk, then we run. One need not be able to remove a bony impacted third molar to remove an anterior tooth conventionally. In the same way, one need not be able to perform subantral augmentation or nerve repositioning before learning how to recognize and treat predictable, mainstream implant dentistry cases.

Widespread involvement on the part of both experts and general practitioners alike is required to bring implant dentistry to the public on an appropriately large scale. One hundred twenty million Americans are candidates for implant dentistry—40% of our population. Today, more than 50% of all Americans are older than age 50, and the number of senior citizens is sharply increasing. Thus, the fastest growing segment of the population is the wealthiest, and occupies the age group that presents the greatest need for implant dentistry.

Approximately 85% of oral surgeons and periodontists and 30% of prosthodontists insert implants, representing 7000 to 8000 implant insertion practitioners. At the same time, estimates of the number of general practitioners who perform implant insertion range from 3.9% to 9.0%, representing another 6000 to 10,000 practitioners. Taken together, fewer than 20,000 practitioners serve the 120 million people in the United States who are candidates for implant

dentistry treatment. Obviously, the demand far exceeds the supply. Increased involvement by general practitioners in mainstream cases will result in a greater number of referrals of the more atypical, challenging cases that implant dentistry experts can and should be treating. In other words, implant dentistry is ready to incorporate the established, traditional, mutually beneficial relationship between general practitioners and the experts to whom they refer complex cases.

General practitioners are the true heroes of dentistry. They are the ones who treat the population at large. Most general practitioners have the prerequisite skills and ability to perform mainstream implant insertion and restoration, and only require the knowledge and confidence to do so. Practitioners who perform tooth extractions, gingival trimming, and suturing can comfortably learn to insert dental implants in mainstream cases. Practitioners who choose to become involved only with the restorative aspects of implant dentistry will find that this book is valuable because it teaches the specifics of mainstream implant dentistry restoration and familiarizes such readers with the insertion phase so they can maintain diagnostic control of the case and interact with an implant insertion practitioner in an informed way.

Because of the predominance of the root form modality, we have devoted three times more chapters to root forms than to any other implant modality. Nonetheless, other beneficial implant modalities increase the scope of treatment. Therefore, this book covers the indications and treatment procedures of all safe and effective modalities with mainstream applications. It is especially important to become familiar with modalities not used in one's practice. They certainly will be encountered, either when a new patient previously treated elsewhere appears in the office, or when another practitioner calls to refer a patient. It is of vital importance to be able to evaluate a functioning implant properly, so as not to subject the patient to unnecessary hardship either by removing a healthy implant or by allowing an implant with an irreversible complication to remain in function.

Whatever your present or future level of education in dentistry, you can be sure that implant dentistry will affect your practice profoundly. *Principles and Practice of Implant Dentistry* shows you how.

CONTENT AND ORGANIZATION

The book is organized to present a logical progression of information to the reader. A unique feature of the book is

the inclusion of teaching cases, which describe step-by-step surgical procedures of the mainstream applications of accepted implant modalities. Through the teaching cases, readers learn not only how to perform each treatment step but also what to be thinking while the step is being performed, all clearly illustrated. The book also discusses what to do in cases thought to be mainstream but that subsequently involve a minor complication, maintenance procedures, how to recognize and treat reversible and irreversible complications, when to refer, legal considerations, and implant dentistry practice management. The clinical and scientific bases of oral implantology are delineated, with emphasis on their direct applications to the advocated clinical protocols, to enable the reader to truly understand exactly *why* we do what we do.

It is important to understand that the step-by-step procedures presented herein are not advocated as being the only acceptable way to achieve the treatment goals. What is presented is known to be safe, effective, and practical. However, valid variations in sequencing, timing, and technique exist. Throughout the step-by-step procedure chapters, common variations are represented either in the body of the chapter itself or in a separate section at the end entitled "Variations and Alternatives." Options not noted in the text may nonetheless be valid, especially in our rapidly evolving discipline, in which new technologies and research are continually influencing how we approach and perform our work. It is wise to keep abreast of developing trends.

Section One, *Fundamentals of Implant Dentistry*, details the essential clinical and scientific information required to provide dental implant treatment.

- Chapter 1, *How to Recognize a Mainstream Case*, provides the reader with tools to recognize *mainstream* cases, those that can be treated safely and predictably and that compose the majority of what one encounters in practice.
- Chapter 2, *Implant Dentistry Nomenclature, Classification, and Examples*, sets the vocabulary that is used throughout the book.
- Chapter 3, *Evaluation of Available Bone*, describes the theory and practice of measuring and evaluating the bone that is used in implant treatment.
- Chapter 4, *Implant Materials, Design, and Fabrication*, discusses biocompatibility, the interrelationships between implant material, design, and method of fabrication, and how these factors influence clinical use.
- Chapter 5, *Implant Insertion and Healing*, discusses how to recognize a compromised host site, heat production during osteotomy preparation, natural oral defense mechanisms that combat infection and facilitate normal healing, the type and distribution of tissues around implants as they heal, the relationship between healing and case sequencing, and the manner in which both soft and hard tissues heal in an implant host site environment.
- Chapter 6, *Tissue Integration at the Implant Interface*, defines the types of tissue integration around different

types of abutment-providing implants and discusses their applicability, how they are achieved, their physiology, and biomechanical considerations.

Section Two, *Evidence-Based Validation of Safety and Efficacy*, contains chapters that discuss research in implant dentistry.

- Chapter 7, *Scientific and Clinical Acceptability of an Implant Modality*, discusses the scientific criteria (i.e., that which constitutes proof that an implant is safe and effective) that must be fulfilled for an implant modality or system to gain professional acceptance, as well as the clinical criteria that determine whether an implant modality or system is practical for general use.
- Chapter 8, *Seminal Studies of the Safety and Efficacy of the Abutment-Providing Implant Modalities*, takes a look at data regarding the comparatively higher bone loss in unimplanted alveolar ridges than in implanted ridges to highlight the preventive aspects of implant treatment, and examines the studies that demonstrate the safety and efficacy of the modalities and systems used in the step-by-step procedure chapters that appear later in the book.

Section Three, *Clinical Practice of Mainstream Implant Dentistry*, contains chapters that detail the clinical aspects of implant dentistry treatment.

- Chapter 9, *Considerations Common to Mainstream Dental Implant Treatment Protocols* discusses those aspects of treatment that are the same regardless of the implant modality or system used.
- Chapter 10 discusses *Root Form Implants: Treatment of Total Mandibular Edentulism Diagnosed for an Overdenture*.
- Chapter 11 discusses *Root Form Implants: Treatment of Posterior Partial Edentulism Diagnosed for a Fixed Prosthesis*.
- Chapter 12 discusses *Root Form Implants: Treatment of Anterior Single-Tooth Edentulism Diagnosed for a Fixed Prosthesis*, including the insertion of an implant into an immediate extraction site, conservative ridge expansion to increase the volume of available bone, and control of the esthetic result by creating a proper emergence profile.
- Chapter 13 discusses *Plate/Blade Form Implants: Treatment of Posterior Partial Edentulism Diagnosed for a Fixed Prosthesis With Natural Co-Abutments*.
- Chapter 14 discusses *Unilateral Subperiosteal Implants: Treatment of Partial Edentulism With Severe Alveolar Ridge Resorption Diagnosed for a Fixed Prosthesis With Natural Co-Abutments*.
- Chapter 15, *Bone Enhancement: Increasing the Volume of Available Bone*, discusses the types, methods, and physiology of various grafting materials; ridge expansion; nerve repositioning; and distraction osteogenesis.
- Chapter 16, *Choosing the Appropriate Implant Modality*, discusses the various considerations related to the selection of the most appropriate implant modality in cases in which more than one may be applicable.

- Chapter 17 discusses *Diagnosis and Treatment of Reversible and Irreversible Implant Complications*, including how trouble can be recognized, how to determine whether the implant can be treated conservatively or must be removed, and how to perform such treatment or removal.
- Chapter 18, *Examples of Intermediate and Advanced Cases*, shows examples of more advanced cases that can be treated when mainstream treatment has been mastered, or that can be referred to an expert.

Section Four, *Non-Abutment-Providing Modalities*, contains chapters that teach the indications and use of procedures that are not designed to provide abutments for restorative dentistry.

- Chapter 19 discusses *Endodontic Stabilizer Implants: Tooth Root Extension for Improved Prognosis*.
- Chapter 20 discusses *Intramucosal Inserts: Increased Retention and Stability of Maxillary Dentures*.

Section Five, *Practice Management*, provides the reader with useful information for running a successful practice that has incorporated implant dentistry treatment.

- Chapter 21, *Diagnosis, Formulation, and Presentation of Goal-Oriented Treatment Plans*, discusses how to assess the physical and psychologic fitness of a patient to undergo an implant procedure, what to do in cases in which the patient does not want or cannot afford optimal care, how to interact with patients, how to understand them, how to motivate them to want the best possible care, certain types of challenging patient types, and common questions and answers that arise when presenting implant dentistry treatment plans.

- Chapter 22, *Referring and Referrals*, describes the solo and team approaches to implant treatment, resources for the referring practitioner, and the ideal relationship between the participants in a referral relationship.
- Chapter 23, *Legal and Insurance Considerations*, discusses the legal components of accountability for treatment rendered, and provides an overview of the growing role of insurance in the practice of dentistry.

Finally, a comprehensive glossary provides definitions of the common and uncommon terms used in implant dentistry.

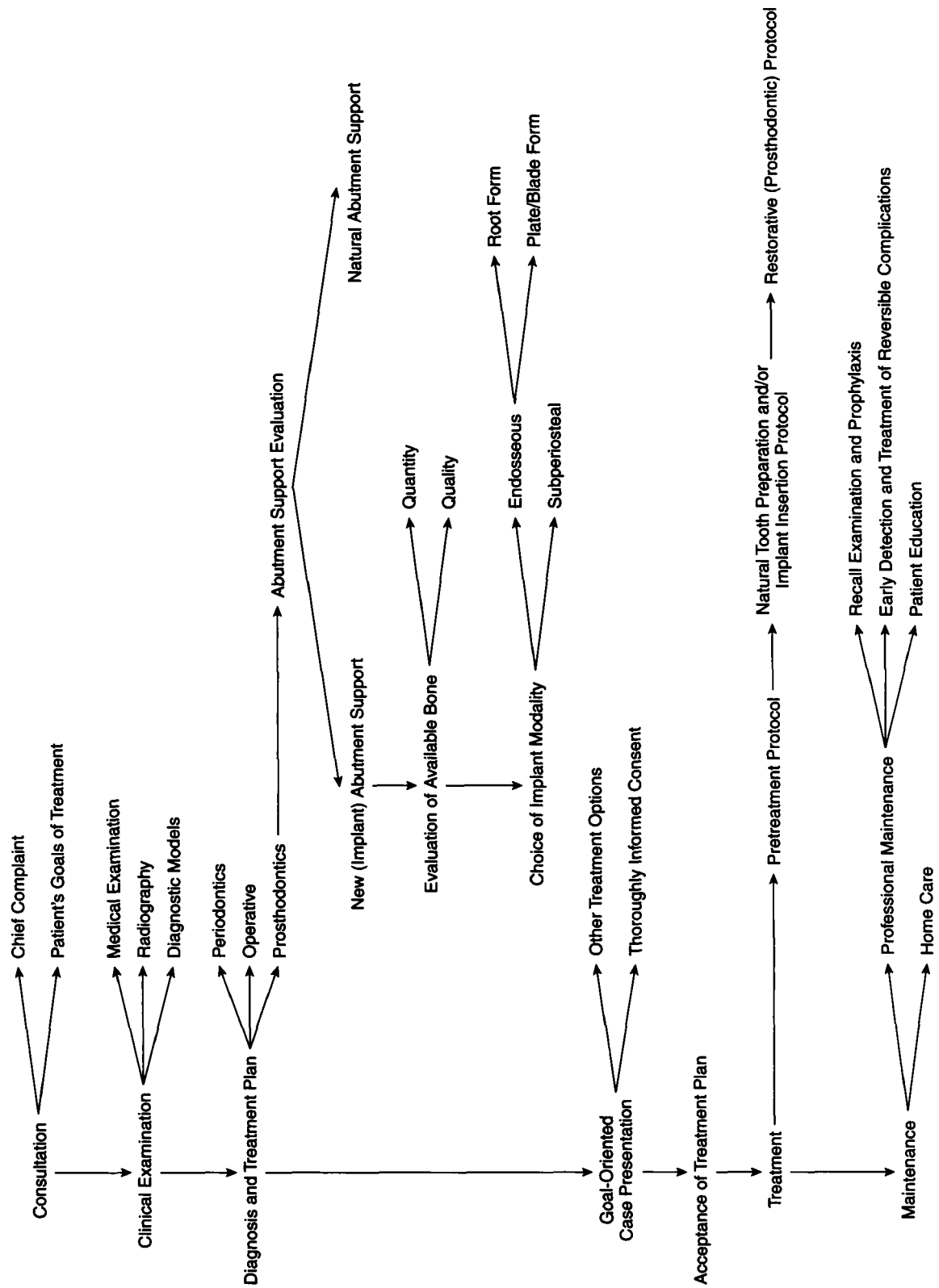
SPECIAL FEATURES

Several special pedagogic features found in this book facilitate use by the reader. Immediately following this preface, a comprehensive flowchart shows the course of events recommended in this book for the treatment of a patient with multimodal implant dentistry, from consultation through aftercare. Controversy boxes highlight points of common disagreement in the field and show both sides of these issues. The step-by-step procedure chapters contain two types of text formatting—regular text that tells the reader “what the hand is doing” and italicized text set against a yellow screen that tells the reader “what the mind is thinking”—to teach more thoroughly not only *how* steps are performed but also *why* they are performed in that way, or in that order. Finally, terms that are defined in the glossary are in boldface type on first appearance in the book.

CHARLES M. WEISS

ADAM WEISS

Implant Dentistry Diagnosis and Treatment Planning **MASTER FLOWCHART**



Acknowledgments

Special acknowledgment is due to John Schrefer, our publishing director, and Penny Rudolph, our editor. Their support, understanding, and advice have made this book possible. We would also like to express our gratitude to Kim Frare, our developmental editor, for her level-headed input, guidance, and support throughout this project; to Anne Salmo, our production editor, for her insightful, thorough, and sensitive editing; and to Teresa Breckwoldt for her wonderful contributions to the design of our book.

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PERSONAL ACKNOWLEDGMENTS

I sincerely appreciate those who have given me their love and support throughout the years. I particularly want to express my respect and admiration for the sheer strength of character and intelligence exhibited by the pioneers of implant dentistry, with many of whom I shared exciting experiences during the development of our field. All of you, collectively, represent a national treasure. The dental profession is in your debt.

My wife, Phyllis, has been personally involved with implant dentistry for more than three decades and has assisted in thousands of implant surgeries. Few people, as the years have unfolded, have experienced more joy and more angst with implant dentistry than she. I am forever grateful for her steadfastness, loyalty, and love. The love and support of our children has been a mainstay of my life. To Joanne, Catherine, Caroline, Anastasia, Adam, and Benjamin, I return your love and support with every fiber of my body. There is no way to express the depth of my feelings toward each of you. I am blessed. To our grandchildren Aaron, Michael, Ian, Christian, Alexander, Alexandra, Zoe, Eliza, Benjamin, Carolina, Alfredo, and Kai, I return your love and pledge to be there for you in every way that I can.

I am fortunate to have been able to co-author this book with my son, Adam. He taught me so much—a love for the English language, the importance of being precise and accurate, respect for the written word. The joy of having worked on this project, of all the hours together, of getting to know him, is real. I am so very proud of him.

Shankar Iyer, his wife Preeti, and daughter Easha are also part of our family. They are a constant source of support, pleasure, and love.

Herbert Meeker is the brother I always wished I had. I cannot think of him without smiling. Leonard Linkow—what can I say? We've come to know and understand each other well in recent years. We are friends. Solely because of Leonard Linkow, implant dentistry is 20 years ahead of where it would have been without him. I wish him every happiness.

Katsura Omura, Bruce Blanket, and Felipa Magundayao are dear and trusted friends. I am lucky to have known them for so many years. Simon Heifetz, who is brilliant, straight, and articulate, taught me more than I can say. I thank him. James Matarese, whose vital contributions to the fabrication of titanium implants are not generally known, has been a pivotal figure in my life.

Although I do not know him personally, I want to acknowledge the very meaningful contributions of Per-Ingvar Branemark to our field.

In my early years of practice, I focused on the then-emerging field of dental practice administration. Al Purinton, L.D. Pankey, Otto Reiser, and Roy Garn shared gifts of knowledge for which I remain grateful every day.

How fortunate I am to have made so many friendships in implant dentistry. Some of those who have especially and positively influenced my life and thinking include Burton Balkin, Gianvincenzo Bartoli, Ken Beecham, Raul Beraha, Sidney Berger, Perry Bingham, Valentine Block, Robert Buhite Sr., Joseph Buttacavoli, Raphael Chercheve, Angelo Chiarenza, C. Benson Clark, Max Clark, Craig Cooper, Norman Cranin, Ronald Cullen, Gustav Dahl, Mark Davis, Triny De Franco, Pierre Doms, Dean Doyle, Fran DuCoin, Ronald Evasic, Alfred Feigel, Aaron Gershkoff, Harris Goldman, Kim Gowey, Richard Guaccio, Gintas Gumbelevicius, Jack Hahn, Boyd Harris, Gerhardt Heidelberg, Alfred Heller, Yasunori Hotta, Noriharu Iikumi, Marilyn Jackson, Harold James, Choul Jin-Row, Paul Johnson, Jean-Marc Juiller, Toshitaka Kaketa, Robert Katz, Hariyuki Kawahara, Kenneth King, Walter Knouse, Eiichi Kojima, Tatsuro Komuro, Frank LaMar Sr., Isiah Lew, Sebastiano LoBello, Leonard Machi, Max Malin, Charles Mandell, Dan Manelli, Emile Martin, Jiro Masuda, Gene McCoy, Ralph McKinney, Raul Mena, Paul Mentag, Edward Mills, John Minichetti, Carl Misch, Arthur Molzan, Fukuo Morita, Giordano Muratori, Karima B. Mohammed, Wenzyl Myska, Louis Naman, Pankaj Narkhede,

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Through the years, my greatest professional joy has been my dental practice. I cannot wait to get to work each morning. After so many years, it is rare that I encounter something clinically that I have not treated before, and when that happens it is exciting. But what is exciting every day are the patients. They are all different, and I take pleasure in each of them. They become like an extended family, and each day brings happy reunions that far outweigh the problems we all experience. However, my "real" professional family is my staff. I could never have written this book without them, and they have enabled me to do more than I could have imagined. Ionie Yvonne Dacres is my surgical assistant. I spend more hours with her than with almost anybody. Operating with her is like being in a ballet: everything moves and is timed and coordinated beautifully. She is skilled and intuitive, and offers me valuable advice and guidance every day. Also, she is a pleasure to be around. I am also thankful to David Gonzalez, my trustworthy and sharp-minded financial consultant and confidant; Dianne Polite, my extremely capable and personally excellent office manager; Lisa Miller, my thoroughly professional and valued new hygienist; and Latoya Ford and Laura Rivera, high school students in our office on a special program, both obvious winners personally and in

terms of their natural abilities. You are a wonderful staff, and I know how lucky I am to have you. Also, I express my appreciation to Boris Abayev of Advanced Dental Laboratory, New York, for his caring and excellence in all he undertakes.

I also want to acknowledge the American Academy of Implant Dentistry (AAID) and its specialty board, the American Board of Oral Implantology/Implant Dentistry (ABOI/ID), and the wonderful staff of each. The contributions of this academy and board to our profession are boundless. Most of the advances of the past 50 years have been made by members of the AAID and ABOI/ID. The year 2001 marks the fiftieth anniversary of the AAID, something the entire profession can celebrate.

CHARLES M. WEISS

PERSONAL ACKNOWLEDGMENTS

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ADAM WEISS

1 How to Recognize a Mainstream Case

The simple truth that one should start at the beginning is sometimes overlooked in **implant dentistry**. Practitioners must heed many factors before being ready to insert and restore a **dental implant**, but one consideration supersedes all others: What is a mainstream case, and how can it be recognized (see Controversy box)? Understanding this is paramount because the way to begin is with the treatment of simple, predictable cases.

CONTROVERSY

What is Mainstream?

The term *mainstream* is used carefully in this book. The term is not intended to mean that which is the most popular. The question is not whether an implant *modality* is considered mainstream. If an implant modality has been proved to be safe and effective for its intended purpose, the question becomes which cases can be considered mainstream for treatment using a professionally accepted modality. This chapter seeks to establish guidelines for recognizing those cases that are safe and predictable, represent the majority of what practitioners encounter, and can be routinely treated by a competent practitioner—that is, “mainstream” cases.

Mainstream implant dentistry cases share several characteristics that, taken as a whole, are easy to understand because they are essentially the criteria used to determine whether any dental procedure is mainstream (Box 1-1).

MAINSTREAM CASES ARE CLOSE TO IDEAL

The concept that mainstream cases are close to ideal may sound self-evident; nonetheless, being mindful of this tenet is vital when determining whether the case at hand can be considered mainstream. No case is ideal; however, mainstream cases come close. They meet the following conditions: (1) rarely involve **complications** or atypical conditions; (2) should involve implant insertion in healed partially edentulous spans, or in immediate or healing extraction sites only under ideal conditions (see Controversy

box), (3) should require only minor **bone enhancement** procedures, if any, and (4) should not require complex out-of-office diagnostic radiography.

CONTROVERSY

Insertion in Immediate Extraction Sites

Some dental implant practitioners hold that insertion of implants in immediate extraction sites can and should be performed routinely. Others believe that in all cases, the extraction site should be allowed to completely heal before insertion is attempted. University of Tübingen research presented in Chapter 8 indicates that under certain conditions this type of treatment can be administered with confidence.

The two main considerations in such cases are available bone and infection control. The osteotomy of an immediate extraction site should obliterate the walls of the socket in every dimension. The presence of infection must also be carefully considered. Why was the tooth extracted? What is the condition of the host site? Implantation into an immediate extraction site should only be attempted in cases in which any minor infection or inflammation that may be present is well controlled.

When considering implantation into an immediate extraction site, it is valuable to remember that allowing the site to heal first is always an acceptable option. Chapter 12 provides step-by-step instruction in immediate extraction sites cases.

MAINSTREAM CASE INSERTION IS HIGHLY PREDICTABLE

Cases in which only one or a few teeth are missing are the most technique-permissive and have the most favorable prognosis. One should begin with this type of case. The exception is treatment of a fully edentulous mandible using root forms supporting an overdenture. This type of case also is considered mainstream because of its simplicity, and because the area targeted for implantation—between the **mental foramina** in the symphyseal region—is a limited edentulous span. Most implant candidates are partially edentulous and require simple, predictable treat-

BOX 1-1 ■ CHARACTERISTICS OF MAINSTREAM CASES

- They rarely involve complications or atypical conditions
- They are only performed in healed alveolar ridges, or in healing or immediate extraction sites only under appropriate conditions
- They do not require extensive bone enhancement
- They do not require out-of-office radiography
- They are predictable
- They are performed in mainstream patients
- They are preventive dentistry
- They require restorations of five or fewer units
- They are performed in cases in which the alveolar ridge is of appropriate dimensions to accommodate the selected implant
- They use professionally accepted implant modalities

ment that can be considered mainstream. The key is to screen for those cases that are advanced. Such cases should be referred to an experienced practitioner for treatment.

MAINSTREAM CASES REQUIRE MAINSTREAM PATIENTS

As in all interventional dentistry, a case that appears to be clinically ideal may ultimately prove not to be because of physical and emotional considerations related to the patient. Any condition that compromises metabolism or healing is a cause for concern. Examples of possible contraindications that require consultation with a physician include uncontrolled diabetes, existence of an active malignancy, recent history of chemotherapy or radiation therapy, any immunodeficiency disorder, cardiovascular disease, osteoporosis, liver diseases, certain blood dyscrasias,¹ and in general any other conditions that contraindicate oral surgery.

A patient with a mainstream case presentation and reasonably good health may still not be considered mainstream because of detrimental personal health practices such as heavy smoking,^{2,3} alcohol or drug abuse, poor diet, high stress, compulsive bruxing, or poor oral hygiene.⁴

In addition to physical considerations, the practitioner must evaluate the mental fitness of the patient.⁵ Is the patient psychologically prepared to undergo a surgical procedure? Use the same caution in this regard as for any other surgical procedure, keeping in mind that implantation itself can have a unique psychologic impact.⁶ Most long-time implant practitioners have treated at least one patient with healthy, fully functional implants who requests that the implants be removed for no reason other than that the patient must “get them out.” As much as possible, patients with the potential to have this type of psychologic reaction should be identified beforehand through screening and avoided.

As in any procedure, patients who may seek to file an unwarranted lawsuit also should be avoided. One of the best ways to screen for such patients, as well as for those who may not be mentally or psychologically fit for implant dentistry treatment, is to obtain **truly informed consent**. Obtaining a signature on a release form for legal protection is not the same as obtaining informed consent. Does the patient really understand what the treatment entails? Has the diagnosis, treatment plan, and prognosis been described in the greatest detail that is appropriate? Have all alternative treatment plans been discussed, including their associated benefits and risks? Many of the patients who may eventually present trouble are in fact incapable of giving truly informed consent, even if they do sign a consent form. Certain questions they ask, or attitudes they exhibit, may act as warning signs. For example, some patients insist that the success of their treatment be guaranteed. This, of course, is not always a reasonable or realistic expectation, and may be a warning sign of a potentially troubled patient.

Finally, the practitioner must determine whether the patient is able to pay a fair fee for the proposed implant treatment. It is unfortunate but nonetheless true that not everyone can afford optimal treatment for his or her condition. In such cases, the practitioner may either reduce the fee, arrange to receive payment in installments, or offer an alternative salutary treatment plan.

These patient-related considerations are discussed in detail in Chapter 21.

MAINSTREAM CASES ARE PREVENTIVE

Restoration with a fixed bridge that utilizes the additional **abutment** support provided by dental implants is preventive dentistry,⁷ because it helps to arrest the serial loss of natural teeth associated with removable partial dentures.⁸ Although properly designed partial dentures can function successfully long-term,⁹ natural teeth that are clasped or otherwise attached to removable partial dentures for **stability** and **retention** are often compromised because of excessive and/or poorly directed force. A natural tooth that is clasped to support a removable partial denture can be subjected to force beyond that which nature designed it to withstand. This occurs because the tooth bears a load that would have been shared by the missing teeth the partial denture was fabricated to replace. Furthermore, because the clasp produces excessive horizontal **stress**, the tooth is subjected to vectors of force it may not be equipped to handle.¹⁰ Natural teeth are designed to withstand substantial vertical force applied in the direction of the long axis of the root. Other reasons that partial removable dentures can lead to the loss of natural teeth include inadequate tooth preparation, lack of guide planes, and poor design and/or location of clasps. Treatment with a fixed bridge supported entirely or in part by additional abutments provided by implant dentistry can help prevent these problems, thereby preserving natural teeth.⁷

In addition, with the use of **endosteal** modalities, the rate of residual ridge **resorption** is retarded compared with that in unimplanted ridges, which do not function for their intended purpose^{11,12}—to envelop natural tooth roots and absorb the functional forces that pass through them. Bone loss almost always adds years to the appearance of the patient. In general, any procedure that conserves what nature originally provided—in this case the natural dentition and its surrounding bone—should be favored.

Other common sequelae that can lead to the premature loss of natural teeth or to other undesirable physiologic conditions in cases that are not treated using dental implants include tipping, flaring, loss of vertical dimension, excessive occlusal force on the remaining natural teeth, opening of contact points, and periodontal problems. Timely implant treatment can help to ameliorate these problems as well.

MAINSTREAM CASES OF PARTIAL EDENTULISM USUALLY REQUIRE PROSTHESES OF FIVE OR FEWER UNITS

The restoration of mainstream cases of partial edentulism is routine in most respects. Substantial differences exist among the modalities in terms of restorative requirements and procedures. These requirements and procedures are described in detail later in the book. However, it is important at this point to understand that in most mainstream cases, restoration is basically conventional.

In nonimplant cases, most conventional fixed-bridge cases are of five or fewer units, for numerous reasons. Most of the patients in our population who are candidates for prosthetic dentistry present with a need for a small bridge, rather than a large one. Furthermore, fabrication of a bridge with a smaller number of units entails lower expense (both for the patient and the practitioner) and is easier and faster for most practitioners to perform. Consequently, the rate of treatment acceptance is higher for small-bridge than for large-bridge cases.

Ideally, for any given patient, implant treatment should first be performed when the serial loss of teeth has just begun. The first teeth to be lost usually are in the molar and premolar regions, where the forces of mastication are four times greater than in the anterior region.¹³ If a case can be treated with implants in this early stage, more extensive treatment may be avoided in the future. Fortunately, if the patient is not treated with implants in this early stage of partial edentulism, the use of root forms restored with an overdenture is one technique-permissive, predictable option in cases of mandibular total edentulism. However, most patients can be treated before they have succumbed to total edentulism, and therefore most of the mainstream cases that present for treatment require a small prosthesis, usually located posteriorly.

MAINSTREAM CASES PRESENT WITH ALVEOLAR RIDGES OF IDEAL DIMENSIONS FOR AN APPROPRIATE IMPLANT

Fundamental to choosing the implant **modality**, **system**, and **configuration** in any given case is evaluation of the available bone. This important subject is considered in depth in Chapter 3. At this point, it is important to understand that in a mainstream case, **length**, **width**, and **depth** of available bone must be sufficient to accommodate an appropriate implant modality and configuration. Furthermore, the axial inclination of the **alveolar process** must be sufficiently close to that required of the implant abutment to be able to achieve prosthodontic parallelism. Finally, interocclusal clearance must be acceptable.

After establishing that the foregoing criteria have been met, the practitioner determines whether the implants deemed appropriate for the available bone can function successfully if they are inserted, heal, and are restored properly. In other words, once in place, can the implants offer sufficient additional support to withstand the occlusal forces that will be applied to the prosthesis? Can they do the job they are supposed to do? How to determine the answer to these questions is presented in Section 3, which provides teaching cases for each modality.

MAINSTREAM CASES USE PROFESSIONALLY ACCEPTED MODALITIES

The mainstream applications of the modalities that are discussed in this book—**root forms**, **plate/blade forms**, **subperiosteal implants**, **endodontic stabilizer implants**, and **intramucosal inserts**—all are professionally accepted.^{14,15} Chapter 8 details the most important of the studies and clinical trials that have contributed to widespread acceptance of the abutment-providing modalities discussed in this book. Each professionally accepted modality meets enough of the following scientific criteria such that they are known to be safe and effective for their intended purpose: the existence of valid human clinical trials, government and/or implant society acceptance or approval, an abundance of long-term clinical data, long-term bone maintenance superior to that of unimplanted ridges, and preservation of the remaining natural teeth. Each of these criteria is discussed in depth in Chapter 7.

All of the modalities covered in this book are professionally accepted.

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2 Implant Dentistry Nomenclature, Classification, and Examples

Continuous effort is required to standardize terms used in the discipline of implant dentistry. Currently, terms too often carry different meanings in articles, brochures, and lectures. To facilitate communication it is important to establish a common vocabulary. This chapter reviews and seeks to standardize the vocabulary used in implant dentistry. A glossary at the end of the book is included as an aid.

VOCABULARY

Dental Implant

A dental implant is a device of biocompatible material(s) placed within or against the mandibular or maxillary bone to provide additional or enhanced support for a prosthesis or tooth. Many published definitions of the dental implant include the concept that its purpose is to provide an abutment for restorative dentistry. However, this definition excludes the endodontic stabilizer, an implant that improves the prognosis of a compromised tooth, which then in turn may or may not be used as an abutment under a prosthesis.

Implant Modality

An implant modality, broadly defined, is a generic category of dental implants. Although individual modalities may overlap in application, each modality is distinct from the others in its **scope of treatment**, diagnostic criteria, possible **mode** or modes of tissue integration, anatomic requirements, and **success** and **survival rates**. Much confusion has resulted from not understanding that the rules, expectations, parameters, and even the philosophies of the use of one modality have little to do with those of another.

Implant System

Different commercial systems are available for most modalities. A system is a specific line of implants. Different root form systems, for example, are produced by Nobel Biocare/Steri-Oss, Innova, Friadent, and a wide range of other manufacturers. Each of these systems is of the same

broad category, the root form modality. A single manufacturer often offers several lines of implants, and each line is considered a different system. Thus, a manufacturer may offer a threaded cylinder system and a press-fit system, and each may be available tapered or parallel-sided, coated or uncoated.

Implant Configuration

Various implant configurations usually are found within each system. An implant configuration is a specific shape or size of implant. A wide array of configurations is available to accommodate the anatomic variations of available bone commonly observed in candidate patients for implant treatment.

MODALITIES, SYSTEMS, AND CONFIGURATIONS USED IN THIS BOOK

The professionally accepted implant modalities with mainstream applications covered in this book are listed in Box 2-1. Each of these modalities meets the scientific and clinical criteria for professional acceptance that are delineated in Chapter 7. These modalities are root forms (Fig. 2-1), plate/blade forms (Fig. 2-2), subperiosteals (Fig. 2-3), endodontic stabilizers (Fig. 2-4), and intramucosal inserts (Fig. 2-5). Modalities that are not covered in this book may not lend themselves to mainstream applications because of clinical considerations such as excessive technique-sensitivity, need for treatment in a hospital environment, or insufficient data to demonstrate high long-term survival rates.

Rather than attempt to delineate the particularities of each implant system on the market—there are product differences both minor and major in every implant system—we have selected our “systems of choice” to represent mainstream treatment within each modality. We have done this for several reasons. First, to take the particularities of each available implant system into account when describing the



FIG. 2-1 ■ Root forms used in teaching cases in this book.

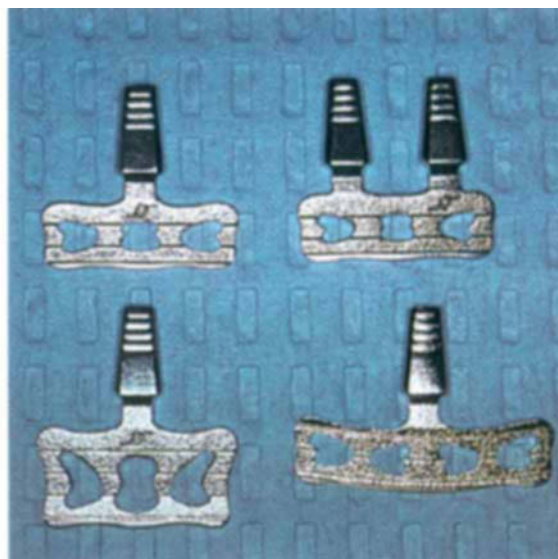


FIG. 2-2 ■ Plate/blade forms used in teaching case in this book.



FIG. 2-3 ■ Unilateral subperiosteal implant of the type used in teaching case in this book.

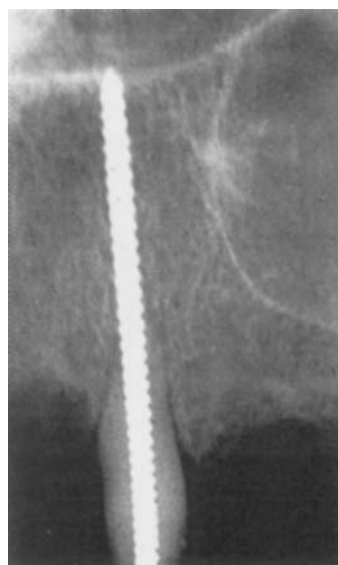


FIG. 2-4 ■ Endodontic stabilizer used in teaching case in this book.



FIG. 2-5 ■ Intramucosal inserts used in teaching case in this book.

BOX 2-1 ■ PROFESSIONALLY ACCEPTED IMPLANT MODALITIES WITH MAINSTREAM APPLICATIONS

Endosteal

- Root forms
- Plate/blade forms
- Endodontic stabilizers

Subperiosteal

- Unilateral subperiosteal implants
- Denture-enhancing
- Intramucosal inserts

step-by-step surgical and restorative procedures would cause the learning curve to be impossibly steep and would make this book prohibitively long. Another all-inclusive approach would have been to genericize any reference to an implant modality, but we rejected this “lowest common denominator approach” because it disallows discussion of the unique benefits of any one system. In a way, taking the generic approach would skirt an issue that we feel responsible to address directly: to specifically identify excellent implant systems that can be used to predictably achieve good results for the mainstream applications identified in this book. We believe that this is the most informative and helpful approach. We have chosen the systems in this book because we know them to be safe, effective, and technique-permissive in their mainstream applications. Just as importantly, the systems described in this book were chosen because they expand the mainstream applicability of the modalities they represent, either because they are more technique-permissive than other available systems, or because they can fit a wider range of available bone. These are the systems that we recommend to our patients. Keep in mind that when we discuss step-by-step procedures, we are referring to the specific implant system utilized in that particular teaching case. Many of the features described for one system are applicable to other systems within the same modality, but some are unique to the system being discussed. If one chooses to use a different system within the same modality, one should become familiar with the similarities and differences between the system chosen and the one shown in this book. Do not assume that the features we discuss for one system apply to other systems. For example, the plate/blade system we use is fabricated by **coining**, which alters the metallographic structure to allow the practitioner a greater margin of safety when bending for parallelism or to follow anatomic contours of available bone¹ (Fig. 2-6). Other plate/blade form systems that are not coined tend to be more **brittle** and therefore allow for less bending. Another example is the root form system chosen for the partial posterior edentulism teaching case restored with individual crowns. Because of the increased surface area and retention of the system’s diffusion-bonded **microsphere** interface with interconnecting porosities, its shallower implants can function as effectively

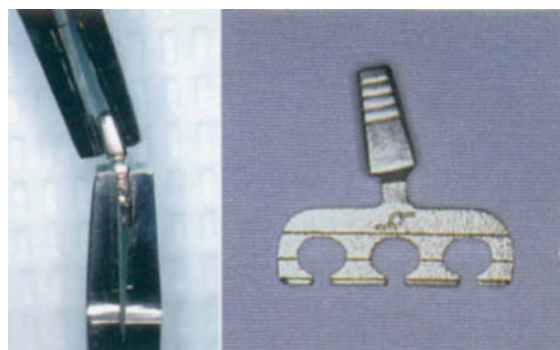


FIG. 2-6 ■ Adjusting plate/blade forms for enhanced parallelism at time of insertion.



FIG. 2-7 ■ Bone growth within interconnecting porosities (left) of diffusion-bonded microsphere interface (right).

as deeper conventional threaded root forms² (Fig. 2-7). This substantially expands one’s scope of mainstream treatment, because these implants can be used in a wider range of unaugmented available bone, and can be inserted at an angle in closer accordance to the requirements of prosthodontic parallelism. It is for these reasons that we chose this implant system to demonstrate mainstream treatment of posterior partial edentulism, where less bone tends to be available than in the anterior. Similarly, the system that represents mainstream treatment of full mandibular edentulism with a root form-supported overdenture requires fewer surgical interventions than many other available systems, and promotes prosthodontic simplicity (Fig. 2-8). The system in the single-tooth replacement teaching case was selected because of the long-term success demonstrated by clinical trials that investigate this specific type of treatment using this implant system, and because its stepped body design (Fig. 2-9) is specifically designed for placement into immediate extraction sites in appropriate cases, again expanding scope of treatment.

Finally, the configurations within each implant system that are described throughout the book are chosen based on the diagnosis and anatomy of available bone of each case.



FIG. 2-8 ■ Root form transfer copings for direct impressioning at time of implant insertion.



FIG. 2-9 ■ Stepped body design for insertion into immediate extraction site.

CLASSIFICATION OF IMPLANT MODALITIES

Endosteal Implants

Endosteal implants comprise one broad category of implants. The most commonly applicable abutment-providing modalities are endosteal. In mainstream cases, endosteal implants are placed within fully or partially edentulous alveolar ridges with sufficient residual available bone to accommodate the selected configuration.

Some endosteal implants are attached to **components** for the retention of a fixed or removable prosthesis. Other endosteal implants are equipped with an abutment inte-

gral with the **implant body**, which protrudes into the oral cavity during healing. Endosteal implant systems are commonly referred to as **one-stage** or **two-stage**. Sometimes these terms are used to describe the number of required surgical interventions. In this book, endosteal implant systems that require attachment of abutments or other **attachment mechanisms** at a visit subsequent to the insertion visit are referred to as **two-stage**, and those that are equipped with an integral abutment at the time of insertion are referred to as **one-stage**. Therefore, what some manufacturers call “one-stage,” meaning that only one surgical intervention is required, is what this book refers to as the two-stage **semi-submersion** healing option, in which a **healing collar** is placed flush with or up to 1 mm above the gingiva at the time of implant placement, thus avoiding the implant exposure surgery associated with **submersion** under the gingiva at the time of implant insertion.

Root Forms. Root form implants are designed to resemble the shape of a natural tooth root. They usually are circular in cross section. Root forms can be threaded, smooth, stepped, parallel-sided or tapered, with or without a **coating**, with or without grooves or a **vent**, and can be joined to a wide variety of components for retention of a prosthesis.

As a rule, root forms must achieve osteointegration to succeed. Therefore, they are placed in an **afunctional** state during healing until they are osteointegrated. Semi-submerged implant healing collars are then removed, or submerged implants are surgically exposed for the attachment of components for the retention of a fixed or removable prosthesis. Thus, most root forms are two-stage implants. Stage one is submersion or semi-submersion to permit afunctional healing (Fig. 2-10), and stage two is the attachment of an abutment or retention mechanism (Fig. 2-11). Semi-submersion of root forms obviates the need for two surgical interventions, which represents an important improvement in the modality in terms of technique-permissiveness. Root form protocols require separate treatment steps for insertion and abutment or retention mechanism attachment whether the healing protocol calls for submersion or semi-submersion.

A root form can be placed anywhere in the mandible or maxilla where there is sufficient available bone. However, because of the diameter of root form implants, most mainstream treatment involves anterior insertion^{3,4} for single-tooth replacement or restoration with overdentures. With the innovation of the diffusion-bonded microsphere interface, the mainstream applicability of this modality has increased in cases of posterior partial edentulism requiring five or fewer units of restorative dentistry. Tapered smooth and threaded cylinders also are fine choices for anterior edentulism. Figs. 2-12 through 2-15 show typical mainstream root form cases.

Plate/Blade Forms. As its name suggests, the basic shape of the plate/blade form implant is similar to that of a metal plate or blade in cross-section. Some plate/blade

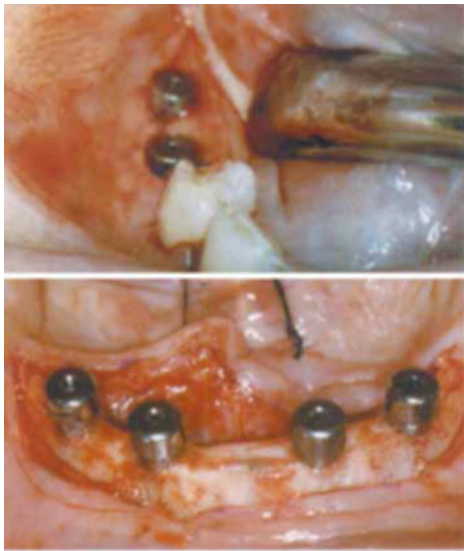


FIG. 2-10 ■ First-stage submerged (cover screws, *above*) and semi-submerged (healing collars, *below*) healing options to achieve osteointegration.



FIG. 2-11 ■ Second-stage prosthesis attachment mechanism following healing.



FIG. 2-12 ■ Root forms to support single-tooth replacements.



FIG. 2-13 ■ Crowns individually supported by root forms.



FIG. 2-14 ■ Root form-supported single-tooth replacement in mandible.

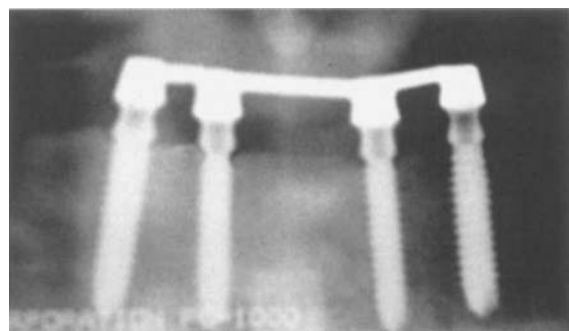


FIG. 2-15 ■ Splinted root forms with coping bar for overdenture retention. (Courtesy Dr. Joel Rosenlicht, Manchester, Conn.)

forms have a combination of parallel and tapered sides (Figs. 2-16 and 2-17). Just as screws and cylinders are both of the root form modality, plate forms and blade forms are both of the plate/blade form modality. Plate/blade form systems are supplied in one-stage and two-stage varieties (Fig. 2-18). One-stage plate/blade form implants are fabricated of one solid piece of **titanium**, with the abutment contiguous with the body of the implant. Two-stage plate/blade form implants are supplied with detachable abutments and healing collars. The one-stage and two-stage options exist so the practitioner can use the osteointegration or **osteopreservation** mode of tissue **integration**, according to the needs of the case. These modes of tissue integration are introduced in Chapter 6. Considera-

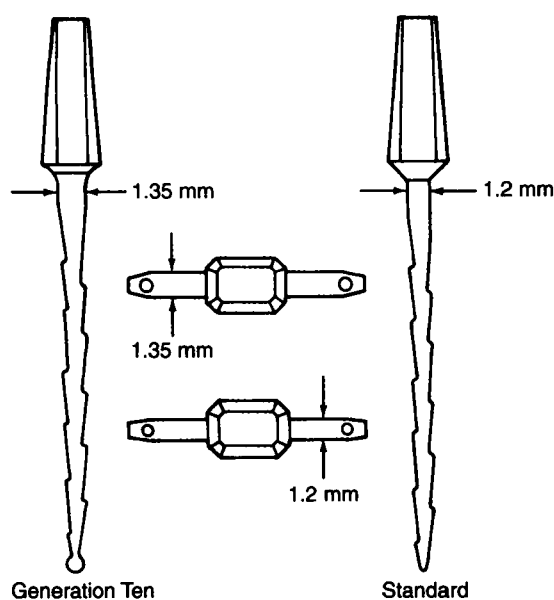


FIG. 2-16 ■ Profiles of Generation Ten and Standard plate/blade form implants.

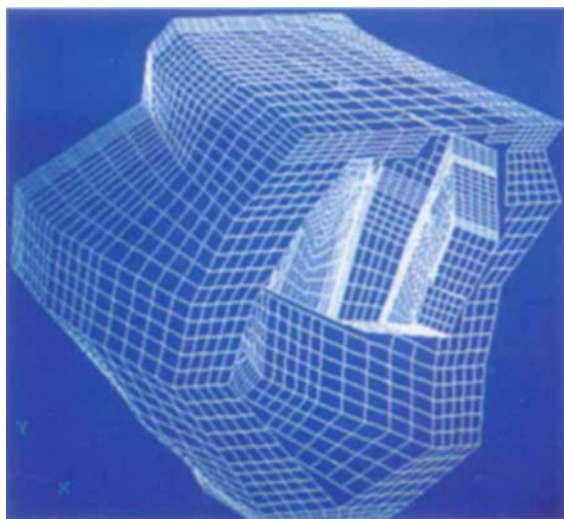


FIG. 2-17 ■ Three-dimensional finite element model of plate/blade form with combination of parallel and tapered sides in a mandible.

tions in choosing the appropriate **mode of tissue integration** are discussed throughout the book.

Plate/blade forms are unique among implants in that they can function successfully in either the osteointegration or osteopreservation mode of tissue integration.⁵ When mainstream protocols are followed, one-stage implants heal in the osteopreservation mode of tissue integration, and two-stage implants osteointegrate. As with two-stage root forms, two-stage plate/blade forms require a second treatment step for the attachment of abutments. However, two-stage plate/blade forms are designed to heal in the semi-submerged healing mode, so the second-stage removal of the healing collar and attachment of the abutment does not require a surgical intervention.

As with root form implants, plate/blade form implants can be placed anywhere in the mandible or maxilla where there is sufficient available bone. However, because of their narrower bucco/labio-lingual width, plate/blade forms tend to be applicable in a wider range of available bone presentations, especially in the posterior of the ridges. Plate/blade forms can be used for the majority of implant dentistry candidates, and in 100% of cases in which root forms can be inserted. Figs. 2-19 through 2-21 show radiographs of typical mainstream plate/blade form cases.

Endodontic Stabilizer Implants. Although endodontic stabilizer implants are endosteal implants, they differ from other endosteal implants in terms of functional application. Rather than providing additional abutment support for restorative dentistry, they are used to extend the functional length of an existing tooth root to improve its prognosis⁶ and when required, its ability to support bridgework. Modern endodontic stabilizers take the form of a long, threaded post that passes at least 5 mm beyond the apex of the tooth root into available bone. Endodontic stabilizers have been designed with parallel or tapered sides, smooth or threaded. The most successful endodon-

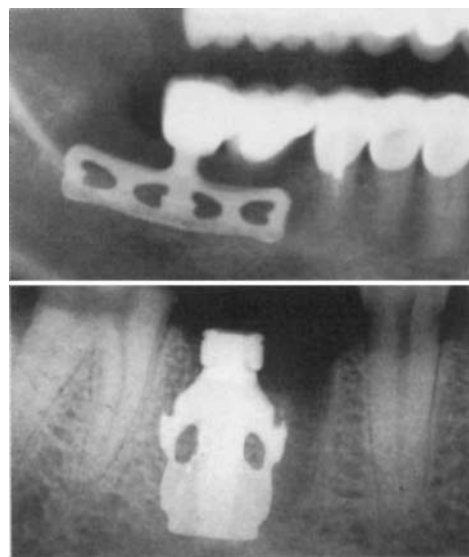


FIG. 2-18 ■ One-stage (*above*) and two-stage (*below*) plate/blade form options.

tic stabilizers are threaded and parallel-sided, with **sluiceways** in the threaded crests that prevent apical cement sealant from being expressed into bone by guiding it crestally. The parallel-sided threaded design controls the stress concentration at the apex of the root, protecting against fracture and trauma.⁷

The endodontic stabilizer functions in the osteopreservation mode of tissue integration, because the tooth root through which it is inserted is subjected to normal physiologic **micromovement** as it heals. Endodontic stabilizers are placed and the procedure is completed in one visit, as the final step of any conventional endodontic regimen.

The range of applicability of the endodontic stabilizer is dictated by the need for at least 5 mm of available bone beyond the apex of the tooth being treated, and the need

to avoid certain anatomic landmarks. Five millimeters of available bone is the minimum that can increase the **crown-root ratio** to an extent sufficient to affect positively the prognosis of the tooth. In the mandible, the first premolar and the teeth anterior to it are good candidates for endodontic stabilization. The second premolar and molars are over the **inferior alveolar canal**, and therefore are usually not good candidates for mainstream endodontic stabilization. In the maxilla, the teeth most often treated are the centrals, laterals, cuspids, and the lingual root of first premolars. The second premolar and molars are under the **maxillary sinus**, and therefore usually are not good candidates for mainstream endodontic stabilization. Figs. 2-22 and 2-23 show radiographs of typical mainstream endodontic stabilizer cases.

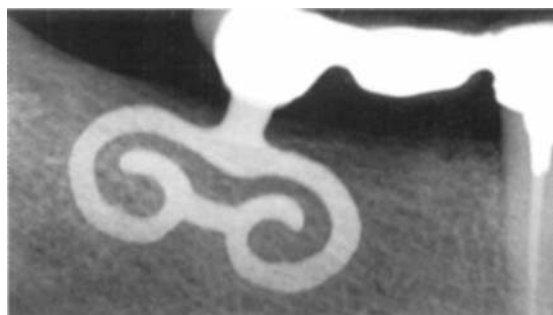


FIG. 2-19 ■ Three-unit fixed bridge supported by plate/blade form with natural co-abutment in mandible.

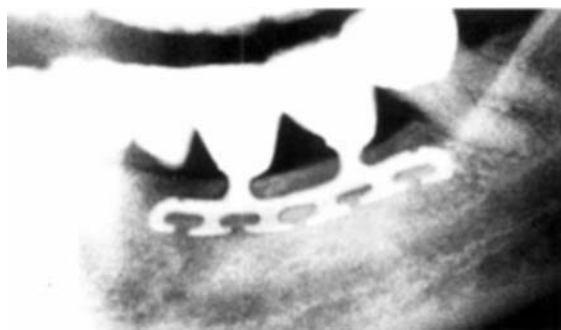


FIG. 2-20 ■ Five-unit fixed bridge with interdental plate/blade form support.

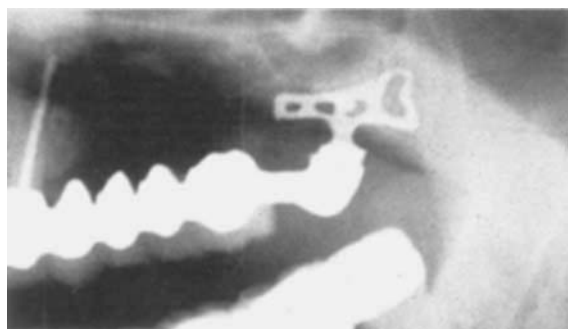


FIG. 2-21 ■ Plate/blade form implant in tuberosity supporting a fixed bridge with natural co-abutments.

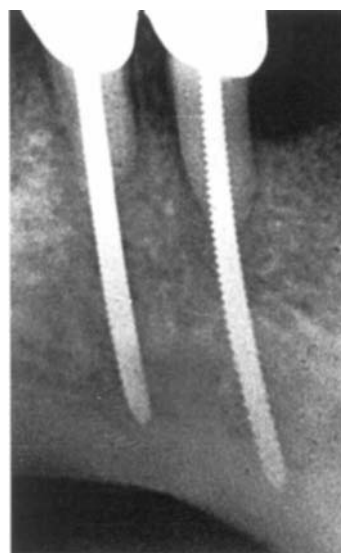


FIG. 2-22 ■ Endodontic stabilizers lengthening tooth roots in anterior mandible.

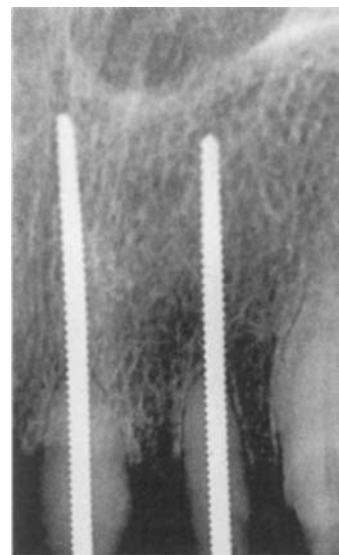


FIG. 2-23 ■ Endodontic stabilizer lengthening tooth roots in anterior maxilla.

Ramus Frame Implants. Ramus frame implants have been demonstrated to be safe and effective. They are intended for the treatment of total mandibular edentulism with severe alveolar ridge resorption. Ramus frame implants do not have mainstream applications because of technique-sensitivity. They feature an external attachment bar that courses a few millimeters superior to the crest of the ridge from ascending ramus to ascending ramus. Posteriorly on each side, an endosteal extension inserts into available bone within each ascending ramus. Anteriorly, the bar is contiguous with a plate/blade form type of extension that is inserted into available bone in the symphyseal area.⁸ Fig. 2-24 shows a radiograph of a ramus frame in position.

Transosteal Implants. Among endosteal implants, transosteal implants are the most surgically invasive and technique-sensitive. As with ramus frame implants, they are limited to the mandible. Although transosteal implants have proven safety and efficacy, they are not considered mainstream because of their complexity and the demands they make on both the practitioner and the patient. Transosteal implants feature a plate that is placed against the exposed inferior border of the mandible, with extensions that pass from this plate through the symphyseal area, out of the crest of the ridge, and into the oral cavity.⁹ This is usually a hospital-based procedure. Fig. 2-25 shows a presentation model of a typical transosteal implant case in the mandible.

Subperiosteal Implants

The subperiosteal implant modality is distinct from the endosteal implant modalities in that the implant is placed un-

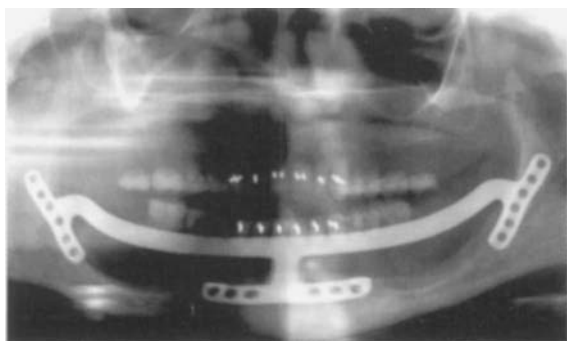


FIG. 2-24 ■ Mandibular ramus frame implant with overdenture. (Courtesy Dr. Jerry Soderstrom, Rapid City, SD.)



FIG. 2-25 ■ Presentation model of transosteal implant.

der the **periosteum** and against bone on the day of insertion, rather than within alveolar bone. This modality is used in cases of advanced alveolar resorption, in which the volume of the residual available bone is insufficient for the insertion of an endosteal implant.¹⁰ The subperiosteal implant is retained by **periosteal integration**, in which the outer layer of the periosteum provides dense fibrous envelopment and anchors the implant to bone through **Sharpey's fibers**,¹¹⁻¹³ and also by retentive undercut features of the implant design. Subperiosteal implants are custom-made and are of four types. Unilateral subperiosteal implants usually are placed in severely resorbed premolar and molar areas of the mandible or maxilla, where there are no distal natural abutments. Figs. 2-26 and 2-27 show radiographs of typical mainstream unilateral subperiosteal cases.

An interdental subperiosteal implant spans a severely resorbed edentulous area between remaining natural teeth. These implants can be used anteriorly or posteriorly in either arch. They are rarely indicated but nonetheless are considered mainstream in the rare cases in which they are applicable. Fig. 2-28 shows a radiograph of a typical mainstream interdental subperiosteal case in the maxilla.

Total subperiosteal implants are for patients who have lost all of their teeth in one arch (Fig. 2-29). Such treatment is not considered mainstream but can be performed after experience with a number of unilateral or interdental cases.

Finally, a circumferential subperiosteal is a modification of a total subperiosteal implant but is used in cases in which several anterior teeth are still in position. Circumferential subperiosteal cases are most often mandibular. The lingual and buccal **main bearing struts** are designed such that the **connecting struts** are distal to the last natural tooth on each side, allowing the entire implant to pass over the anterior teeth to rest against **basal bone**. The circumferential subperiosteal is akin to two unilateral subperiosteals that are connected with anterior labial and lingual main bearing struts.

In mainstream unilateral subperiosteal treatment, two surgical interventions are required—the first to take a direct bone impression to obtain a model from which the custom-made implant is fabricated, and the second to place the implant. Although the application of **computer-generated bone modeling** is promising (Fig. 2-30), it is not yet considered to be a mainstream technique for obtaining an accurate bone model in unilateral cases.



FIG. 2-26 ■ Unilateral subperiosteal implant in mandible.

Intramucosal Inserts

Intramucosal inserts differ in form, concept, and function from the other modalities. They are mushroom-shaped titanium projections that are attached to the tissue surface of a partial or total removable denture in the maxilla¹⁴ and plug into prepared soft-tissue receptor sites in the gingiva to provide additional retention and stability. Thus, they provide support for a prosthesis but do not provide abutments. They are used in the treatment of patients for whom endosteal or subperiosteal implants are not deemed to be practical or desirable.

Intramucosal inserts do not come into contact with bone, so the mode of tissue integration is not osteointe-

gration, osteopreservation, or periosteal integration. Rather, the receptor sites in the tissue into which the inserts seat become lined with tough, keratinized **epithelium**. In this sense, seated intramucosal inserts are external to the body. Only one appointment is required for the placement of intramucosal inserts.

For reasons that are described in detail in Chapter 20, intramucosal inserts are best used in the maxilla. Because of complicated **biomechanics**, more acute alveolar ridge angles, a wider array of applied forces, and insufficient gingival thickness, placement of intramucosal inserts in the mandible is not recommended. Figs. 2-31 and 2-32 show radiographs of typical mainstream intramucosal insert cases in the maxilla.



FIG. 2-27 ■ Unilateral subperiosteal implant in maxilla.

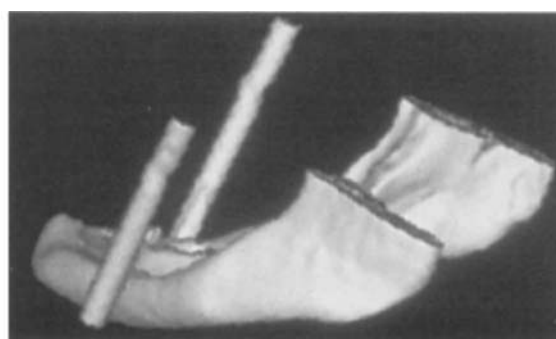


FIG. 2-30 ■ Computer-generated mandibular bone model. (Courtesy Dr. Jerry Soderstrom, Rapid City, SD.)

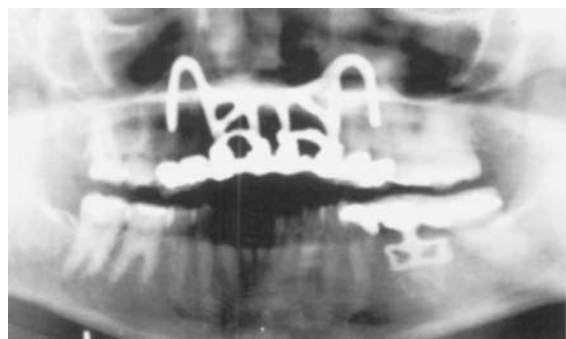


FIG. 2-28 ■ Interdental subperiosteal implant in anterior maxilla. (Courtesy Dr. Terry Reynolds, Atlanta, Ga.)

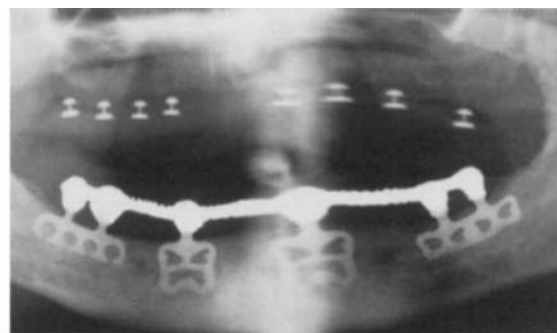


FIG. 2-31 ■ Large intramucosal inserts in position.



FIG. 2-29 ■ Total mandibular subperiosteal implant. (Courtesy Dr. Walter Knouse, Lumberville, Pa.)

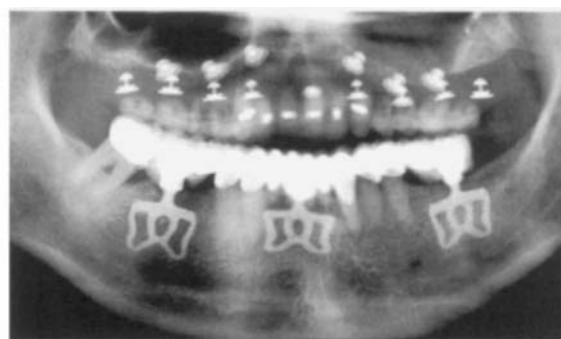


FIG. 2-32 ■ Standard intramucosal inserts in position.

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3 Evaluation of Available Bone

Once a partially or totally edentulous patient in acceptable physical and psychologic condition has been identified as a candidate for implant treatment, the most important consideration is **available bone**. The available bone dictates whether the patient should be treated with an endosteal or a subperiosteal implant. If the volume of available bone is sufficient, use of an endosteal implant is preferable. Endosteal implant insertion is less complex than subperiosteal implant placement and involves fewer complications long-term. The subperiosteal implant is chosen when the amount of available bone is insufficient for the insertion of an endosteal implant. Thus, when an endosteal implant is indicated, usually a subperiosteal implant is contraindicated, and vice versa. In borderline cases, one should favor the use of an endosteal implant if possible. In most endosteal cases, the amount of available bone will determine whether the root form or plate/blade form modality should be used, and to a great extent will dictate the configuration of the implant that will be used within that modality.¹ This chapter discusses how available bone is evaluated both quantitatively and qualitatively for endosteal and subperiosteal implant treatment. In the chapters that detail the step-by-step procedures for each modality and in Chapter 16 the specific available bone requirements for each modality are discussed, as well as what factors should be considered in cases in which more than one modality may be applicable. This chapter provides an overview of the landmarks and borders that determine the volume of available bone. Accurately quantifying available bone is the first step in the mainstream treatment of an implant dentistry case using any modality, according to the procedures described in the step-by-step chapters.

DEFINITION OF AVAILABLE BONE

As with so many terms that are fundamental to implant dentistry, the definition of *available bone* requires standardization. We recommend that the following definition be adopted: Available bone is that portion of a partially or totally edentulous alveolar ridge that can be used to insert an endosteal implant, or basal bone that can be used to support a subperiosteal implant.

FUNCTIONAL RESPONSE OF AVAILABLE BONE

To understand the significance of the definition of available bone, it is important to have a basic understanding of the physiology of an edentulous portion of an alveolar ridge treated with an endosteal implant. The function of the alveolar ridge is to invest tooth roots and absorb the forces of occlusion that pass through them. When the alveolar ridge becomes edentulous, it is no longer in function, and like everything that falls into disuse in the human body, it begins to **atrophy**. Such is also the case when one wears a cast on a limb for a period to allow a fractured bone to heal properly. Upon removal of the cast, muscular atrophy is easy to observe. Atrophy in the alveolar ridge is commonly known as **resorption**. It is worth noting that putting the alveolar ridge back into function through the insertion of an endosteal implant arrests resorption.^{2,3,4} Just as the alveolar ridge absorbs the occlusal forces that pass through tooth roots when natural dentition is still present, the ridge absorbs the forces that pass through the implant after treatment using an endosteal modality. Chapter 5 details the scientific basis of how this occurs.

QUANTITY OF AVAILABLE BONE Vocabulary

The dimensions of an implant and of available bone should be described using the same terminology and orientation as the dimensions of the alveolar ridge. Thus, available bone has three dimensions: length, width, and depth (Box 3-1). Length is the mesio-distal dimension, width is the bucco/labio-lingual dimension, and depth is measured from the crest of the ridge to the nearest limiting landmark.

General Considerations

A basic precept of implant dentistry is that the implants being used for abutment support in any given case should be able to absorb the greatest possible amount of occlusal force and remain within **physiologic limits of health**, such that the implants have the greatest possible margin of safety. A very important part of achieving this is using

BOX 3-1 ■ DIMENSIONS OF AVAILABLE BONE

Length: mesio-distal

Width: bucco/labio-lingual

Depth: from ridge crest to nearest landmark

the maximum amount of available bone that will benefit the case.

Periapical radiographs are recommended to accurately determine the depth and length of available bone. The width of available bone cannot be quantified on periapical radiographs, because they are two-dimensional. Width is determined clinically. The ridge crest, roof of the alveolar canal, mental foramen, adjacent tooth root, sinus floor, and other landmarks can be outlined directly on a periapical radiograph to clearly indicate the amount of available height and length of bone.

Although panoramic radiographs are useful for showing the relative positions of all anatomic areas under scrutiny, they are not as accurate in quantifying available bone because they tend to show substantial and uneven distortion. Out-of-office radiography is rarely required to assess available bone in mainstream cases.

ANATOMY OF AVAILABLE BONE**Available Bone Boundaries for Endosteal Implants**

Mainstream endosteal implant treatment is performed in partially edentulous alveolar ridges, particularly in the posterior part of the dental arch, and anteriorly for single-tooth replacement. The use of an overdenture supported by root form implants is also considered mainstream, because although the full arch is restored, implant insertion is only performed between the mental foramina in the mandible, or between the anterior borders of the sinuses in the maxilla.

To understand the use of available bone and how it may vary with diagnostic decisions, it is helpful to know when the use of natural co-abutments is indicated and when it is contraindicated. In every partially edentulous mainstream case using plate/blade forms, natural co-abutments must be used to support the prosthesis. Plate/blade form implants cannot support a free-standing single or multiple-tooth prosthesis without the use of natural co-abutments (Fig. 3-1). Cases of total edentulism can be treated using plate/blade form implants without natural co-abutments because the implants are placed anteriorly and posteriorly on both sides, having the effect of complete cross-arch splinting (Fig. 3-2). Because the arch is turned, the case is biomechanically sound. This is considered an intermediate-level procedure. On the other hand, in a mainstream partially edentulous plate/blade form case, the implant and natural co-abutments always function in tandem. Joining them under the prosthesis is biomechanically correct.



FIG. 3-1 ■ Mainstream plate/blade form cases with natural co-abutments.

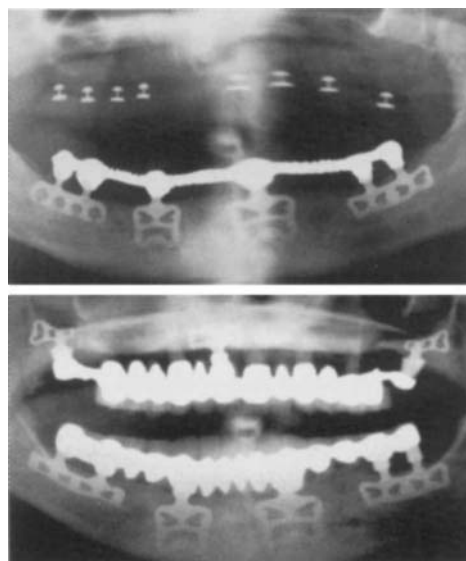


FIG. 3-2 ■ Mandibular complete arch fixed bridges totally supported by plate/blade forms.

When using root forms, for biomechanical reasons it is not advisable to join the implants with natural co-abutments under a bridge.^{5,6} Chapter 6 discusses why mixing different modes of tissue integration to support a prosthesis usually is contraindicated. A series of root forms can also support a complete arch fixed bridge (Fig. 3-3).

The boundaries of available bone vary according to anatomic location. In the mandible, the partially edentulous portion of the alveolar ridge usually is in the area of the premolars and molars. In some cases an interdental endosteal implant may be used as a pier abutment to span an edentulous area between natural abutments, either because

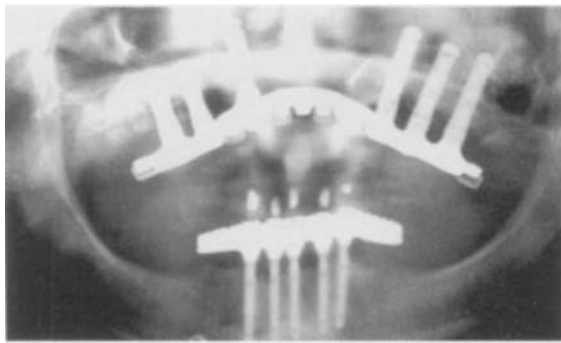


FIG. 3-3 ■ Complete arch fixed bridges totally supported by root forms. (Courtesy Drs. Neal B. Gittleman and R. Kent Stobaugh, Houston, Texas.)

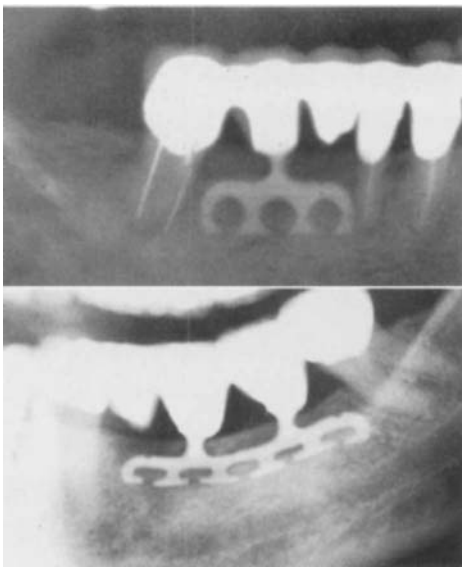


FIG. 3-4 ■ Interdentary plate/blade form implants.

the span is so long that a conventional fixed bridge is not practical, or because in cases of compromised bone support around natural abutments the force to be applied is too great for a conventional fixed bridge to succeed. In such cases the use of one or more endosteal implants, either in sole support of an interdental prosthesis or in conjunction with adjacent natural co-abutments, offers a better prognosis (Fig. 3-4).

In many mainstream cases, an implant is inserted distal to the most distal natural tooth. The distal boundary for the placement of implants in the posterior of the mandible is the ascending ramus. Mesially, the boundary is the distal of the nearest tooth root. If the nearest natural tooth is a first premolar, the position of the mental foramen must also be considered (Fig. 3-5). The mental foramen is located on the buccal, almost always between and slightly inferior to the apices of the first and second premolars. Under no conditions should one impinge on the mental foramen. Distal to the foramen, the boundary of depth is the roof of the alveolar canal (Fig. 3-6). Tracing the course of the inferior alveolar

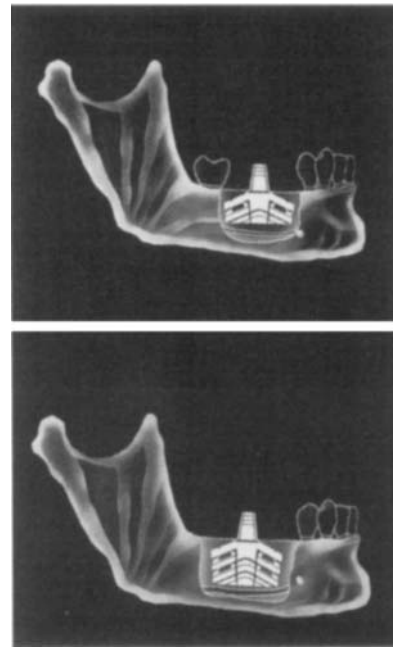


FIG. 3-5 ■ Posterior available bone in mandible, with mental foramen marked. Interdentary and distal implants in position.

nerve as it moves anteriorly shows that the roof of the alveolar canal usually runs a few millimeters inferior to the mental foramen, until it rises to allow the alveolar nerve to pass out of it. As the inferior alveolar nerve travels outward and exits the mental foramen, it rises and turns toward the buccal to supply the corner of the mouth, portions of the lower lip, and the gingiva. Although the inferior alveolar nerve does not take up the entire width of the mandible, its course from the lingula toward the mental foramen is highly variable (Fig. 3-7), even from side to side in the same patient. It is inadvisable to attempt to create an **osteotomy** alongside the alveolar nerve. The risk of impinging on the nerve, thereby causing paresthesia, is too great. The practitioner should consider the boundary of depth for placement of the implant to be 1 to 2 mm superior to the roof of the alveolar canal.

In terms of width, the inserted implant should be invested by 1 mm of bone both buccally and lingually. At the time of insertion of any endosteal implant, the body of the implant is placed at or below the ridge crest (Fig. 3-8). Thus, the width of the ridge 2 mm below the crest should be the width of the implant plus a minimum of 2 mm.

Rarely is there insufficient alveolar ridge width in the posterior area of the maxilla for the placement of some type of endosteal implant. In the premolar area of the maxilla and mandible, the amount of resorption depends on why, how carefully, and how long ago the natural teeth were removed. Insufficient width of alveolar bone is more common in the premolar area of the maxilla than in the molar area (Fig. 3-9).

In the posterior maxilla, the distal boundary of available bone is the distal of the **tuberosity**. The mesial boundary is the distal of the first tooth root anterior to the partially

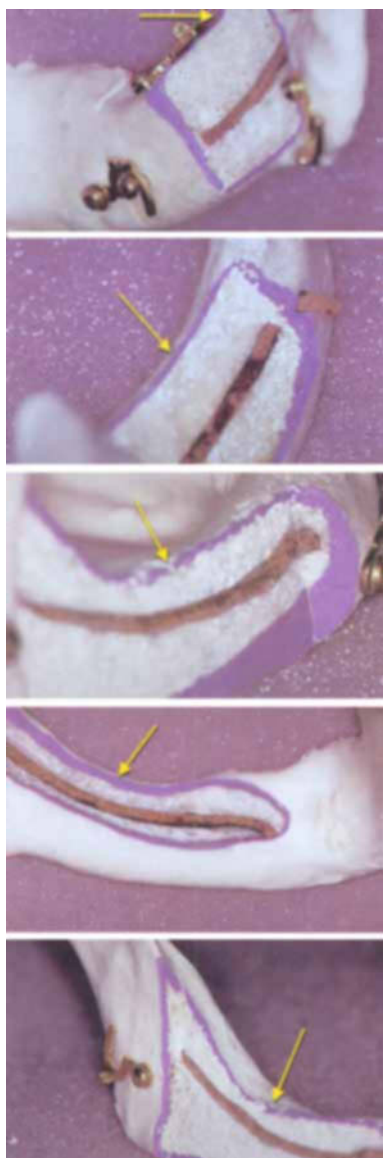


FIG. 3-6 ■ Variations in depth measured from ridge crest (arrows) to superior border of inferior alveolar canal.

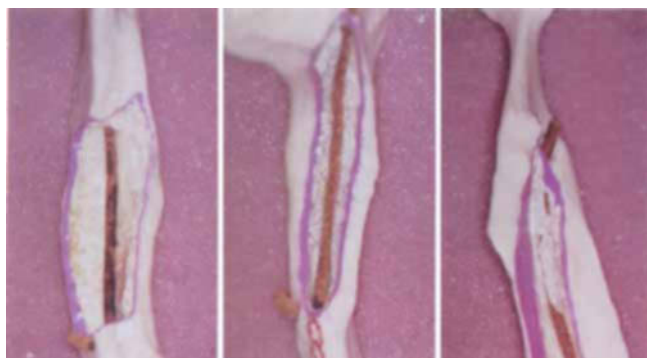


FIG. 3-7 ■ Variations in buccal/lingual course of inferior alveolar canal.



FIG. 3-8 ■ Relationship of ridge crest to coronal portion of inserted root forms (above) and plate/blade forms (below). (Radiograph of root forms courtesy Dr. Craig Cooper, Indianapolis, Ind.)

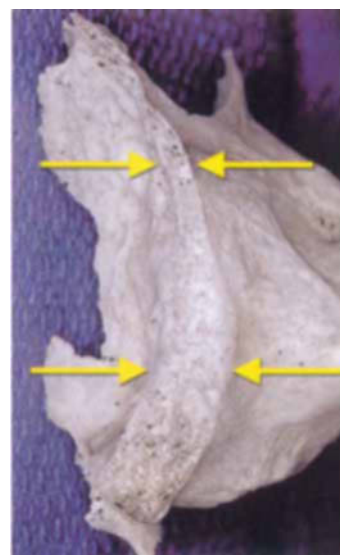


FIG. 3-9 ■ Maxillary ridge crest with wide ridge in molar area narrowing in premolar area (arrows). Commonly observed.

edentulous area. Depth in the posterior maxilla is limited by the extent of the maxillary sinus (Fig. 3-10). Viewed sagittally, this sinus is ovoid or egg-shaped. Therefore, medial to the inferior apex of the maxillary sinus, usually there is available bone into which an osteotomy can be angled by a more experienced **insertion practitioner** (Fig. 3-11). In mainstream implant dentistry, it is best to implant only inferior to the floor of the sinus. The mesio-distal length of this sinus varies patient by patient but usually does not extend anterior to the first premolar area (Fig. 3-12). Occasionally the sinus will extend to the distal of the cuspid area. The extent of the sinus is easy to identify radiographically. A greater depth of available bone usually can be observed anterior to the sinus. In this area, the distal border of available bone is the anterior wall of the sinus (Fig. 3-13).

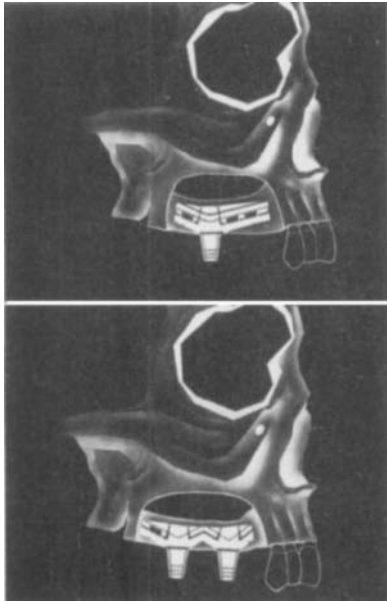


FIG. 3-10 ■ Posterior available bone in maxilla, with sinus marked. Distal implants in position.

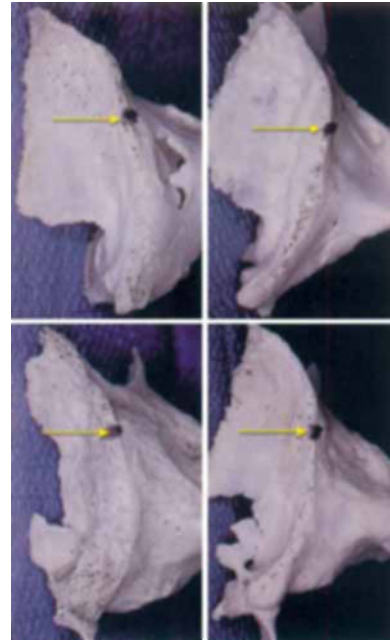


FIG. 3-12 ■ Ridge crest at anterior border of sinus (*arrows*).

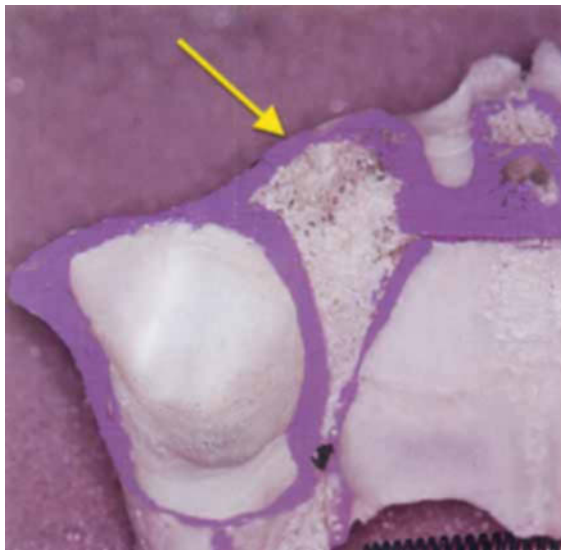


FIG. 3-11 ■ Maxillary sinus viewed from above showing available bone medial to the base of the sinus (*arrow*).

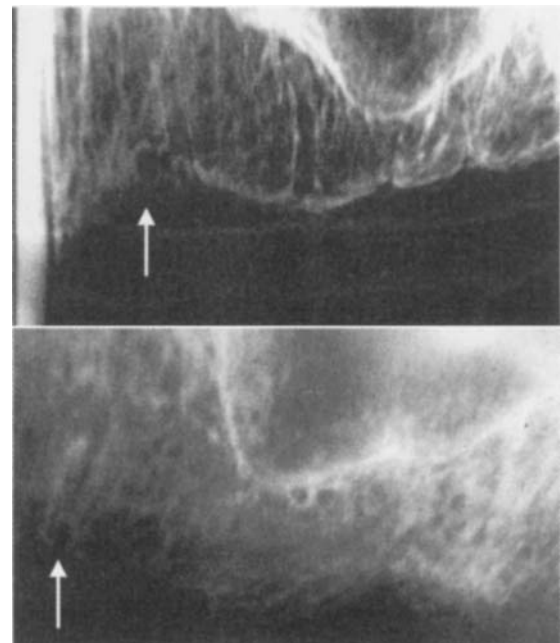


FIG. 3-13 ■ Available bone anterior to maxillary sinus (*arrows*).

In both the mandible and the maxilla, in addition to considering the boundaries of length, depth, and width, one should consider undercuts. As one palpates the lingual of the mandible distally, one encounters the submandibular fossa (Fig. 3-14). An important point to remember in evaluating the extent of available bone is that in most cases the cortical plates of bone are bisected when preparing im-

plant osteotomies. The axis of this bisection usually is not vertical. Penetration almost always is made at an angle to remain in the mid-axis of the residual ridge to avoid undercuts. In the maxilla, account for the canine fossa distal to the canine root (Fig. 3-15).

Soft tissue is an important consideration when quantifying available bone, because the thickness of the gingiva



FIG. 3-14 ■ Inferior aspect of mandible showing submandibular fossa (arrows).

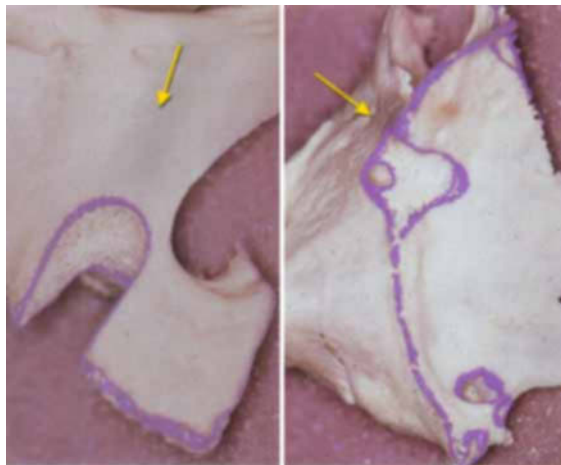


FIG. 3-15 ■ Two views of canine fossa (arrows).

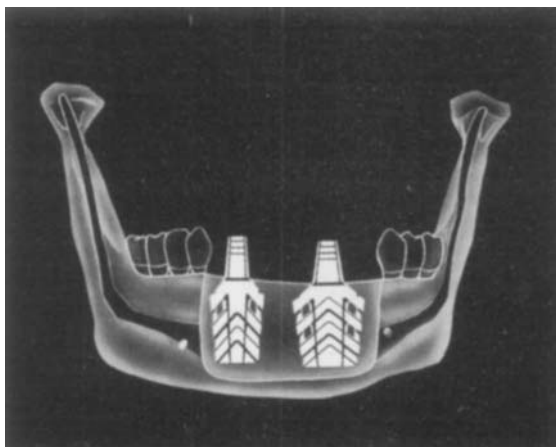


FIG. 3-16 ■ Available bone in anterior mandible with deep interdental implants in position. Note position of mental foramina.

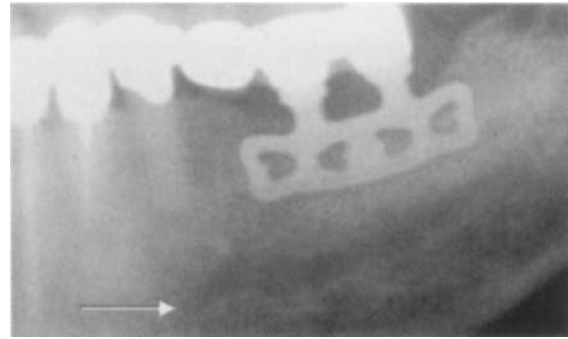


FIG. 3-17 ■ Anterior extension of inferior alveolar canal beyond mental foramen (arrow).

influences the measurement of available bone, particularly of width. In the mandible, the thickness of **attached gingiva** usually is approximately 1 mm. This uniformity facilitates accurate evaluation of the width of available bone. In the maxilla, however, the thickness of the gingiva varies greatly, commonly ranging between 1 and 3 mm, but sometimes exhibiting a thickness up to 10 mm. Some cases that present with particularly thick maxillary gingiva may require minor plastic surgery to reduce soft-tissue bulk before closure. This is necessary to ensure that enough of the abutment will protrude through the tissue, and to reduce **iatrogenic** pocket formation. If not, prosthetics may be complicated by insufficient interocclusal clearance or inadequate area for **cement retention**.

In the evaluation of available bone, the anterior of the mandible is considered to be the area between the mental foramina. In this area, the depth of available bone extends to the inferior border of the mandible (Fig. 3-16). Although in principle it is sound to maximize the use of available bone, in the anterior mandible so much bone is present that using its entire depth sometimes can be unwise. Providing excessive support such that the implants are not subjected to sufficient stress to remain within the physiologic limits of health is what is meant by **overengineering** a case. This can result in bone loss because of **hypofunction**. In some patients, the mandibular nerve extends anteriorly from each mental foramen for a few millimeters. If this is noted radiographically, the extended portion of the inferior alveolar nerve should be avoided (Fig. 3-17). Again, in the anterior mandible, the axis of the osteotomy should bisect the cortical plates. Keep in mind that the mid-axis of available bone slopes toward the anterior with increasing depth. Some of the densest and hardest bone of the body is found in the anterior mandible. In mainstream interdental cases that use this area, the mesial of the nearest natural teeth on the left and right sides or the mental foramina are the boundaries of length. In totally edentulous cases, the boundaries of length are the ascending rami. In edentulous cases diagnosed for anterior implant insertion only, the boundaries of length are from the midline to the mental foramen on each side.

In the anterior maxilla, other boundaries must be considered because of the presence of the nasal cavity

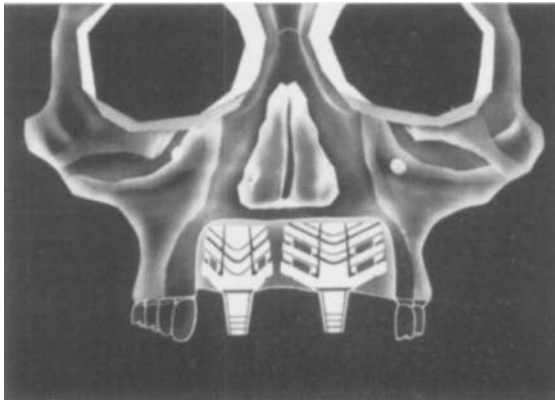


FIG. 3-18 ■ Available bone in anterior maxilla, with implants in position under nasal cavity.

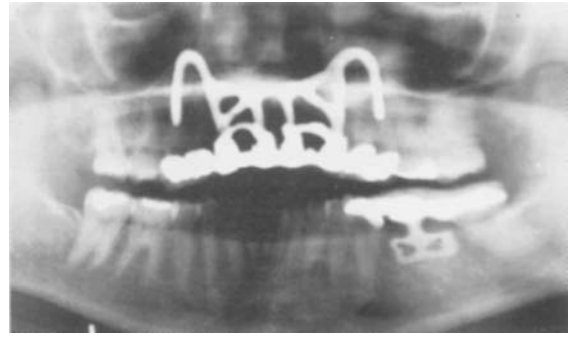


FIG. 3-20 ■ Maxillary interdenal subperiosteal implant. (Courtesy Dr. Terry Reynolds, Atlanta, Ga.)

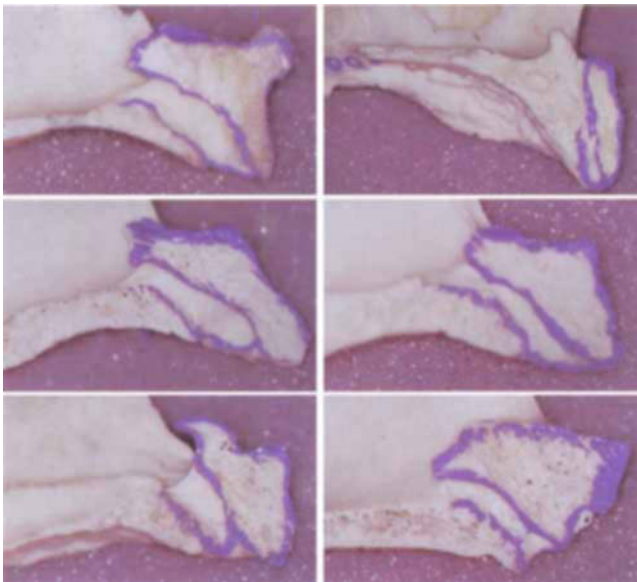


FIG. 3-19 ■ Variations in available bone anterior to anterior palatine canal at midline.

(Fig. 3-18). The floor of the nasal cavity becomes the superior border that limits the depth to which the implant can be inserted. The anterior palatine canal, which passes along the midline and exits on the lingual aspect at the base of the ridge, must also be considered. There is significant variation in canal width and volume of available bone anteriorly (Fig. 3-19). The anterior palatine canal drains the palate and does not supply it. Nonetheless, try to avoid the midline during implant insertion in mainstream cases to avoid the anterior palatine canal.

Available Bone Landmarks for Subperiosteal Implants

Because subperiosteal implants are placed against basal bone, and not within alveolar bone like endosteal implants, landmarks are considered rather than boundaries. Mainstream subperiosteal implant cases almost always are uni-

lateral. Therefore, the anatomy of the basal bone in the posterior of the mandible and maxilla, in the area of the premolars and molars, is of primary interest. Subperiosteal implants are only used in cases of severe bone resorption, when there is insufficient available bone for the insertion of an endosteal implant. In rare cases, an interdenal subperiosteal implant may be indicated to bridge a severely resorbed edentulous area between natural teeth (Fig. 3-20). Although this is considered mainstream, it is rare, because in most interdenal edentulous spans there is sufficient residual alveolar ridge for the placement of one or more endosteal implants. Far more common are cases that call for the placement of a unilateral subperiosteal implant distal to the most distal remaining natural tooth. In such cases, the patient usually has been wearing a removable partial denture for many years and evidences severe posterior alveolar ridge resorption despite the retention of some natural teeth.

In the posterior of the mandible, the landmarks that must be considered for the primary support of a subperiosteal implant are related to the external cortical plates of the basal bone. Basal bone, the relatively fixed and unchangeable framework of the mandible and maxilla,⁷ is located under the alveolar ridge. It is relatively stable throughout the life of the patient. Generally, the superior extent of the basal bone in the mandible is approximately at the level of the alveolar canal (Fig. 3-21). In cases of alveolar nerve **dehiscence**, the superior border of the canal is an important landmark to be avoided during the design phase.

The evaluation of available bone for subperiosteal implant treatment differs radically from that of endosteal implant treatment. To clearly understand how and why these considerations are so different, it is important to have a basic understanding of the biomechanics and physiology of the subperiosteal implant in function. The main consideration in the design and placement of a subperiosteal implant is to determine the optimal locations of the **main bearing struts**. These struts transmit forces through the integrating **sheath** and then to the underlying bone. If force is applied to the abutment of an endosteal implant toward the buccal, the internal aspect of the buccal cortical



FIG. 3-21 ■ Relationship between inferior alveolar canal and ridge crest in resorbed case. Ideal basal bone for subperiosteal implant.

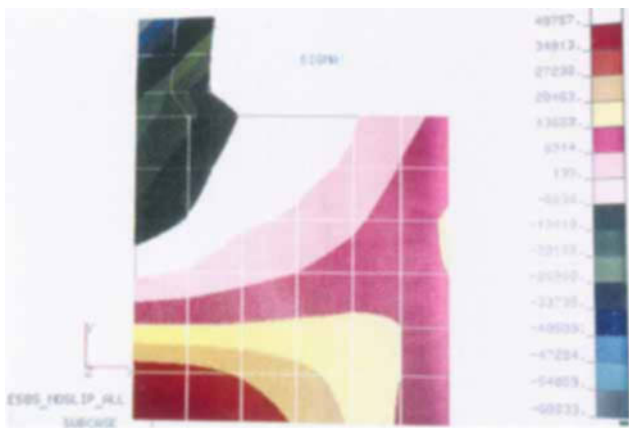


FIG. 3-22 ■ Stress patterns generated within and around endosteal implant.



FIG. 3-23 ■ Mandibular total subperiosteal implant design.

plate absorbs it. However, in the case of a unilateral subperiosteal implant, which sits on top of the bone, force applied to the abutment toward the buccal is absorbed by the external portion of the lingual cortical plate through the main bearing strut, because the implant is external to the bone, rather than within it. Thus, the nature of the absorption of functional force in the case of subperiosteal implants is very different from that of endosteal implants. Because endosteal implants are placed within bone, all functional force vectors are absorbed internally (Fig. 3-22).

However, subperiosteal implants are placed external to bone, and when healed function in fibrous envelopment in the outer layer of the periosteum, which is attached to the surface of the bone, as detailed in Chapter 6. This is termed *periosteal integration*. Anterior forces placed on a mandibular subperiosteal implant are absorbed by the lingual aspect of the mandible, on both sides of and superior to the **genial tubercles**. Horizontal forces from the right are absorbed by the buccal cortical plate of basal bone on the right and the lingual cortical plate of basal bone on the left, anterior to the anterior border of the mylohyoid ridge. The relationship between anticipated forces and subperiosteal design is explained in Chapter 14.

With these considerations in mind, the areas of basal bone upon which main bearing struts should be placed for the absorption of functional forces are as follows: In the mandible, the buccal cortical plates of basal bone on each side distal to the mental foramen are used, including the external oblique ridge up to the ascending ramus. On the lingual, the area of basal bone anterior to the mylohyoid ridge on each side and over the genial tubercle is used. On the labial, the basal bone between the mental foramina over the **mental protuberance** is used.

Connecting struts, which pass between the buccal/labial and lingual main bearing struts, are not for primary support. Their function is to connect the main bearing struts, to unify the implant, and to give rise to **pergingival struts** and abutment attachment mechanisms for the prosthesis. These are placed over the most resorbed areas of the alveolar ridge, as close to each cuspid and the distal of each first molar area as possible for prosthodontic convenience (Fig. 3-23).

In the maxilla, main bearing struts are placed buccally and labially on both sides, starting distally against cortical plates of basal bone lateral to the tuberosity, and then against the underside of the **zygomatic arch**, into the canine fossa and over the canine eminence, and anteriorly under the **anterior nasal spine**. Lingually, they are placed on cortical plates of basal bone at the junction of the residual alveolar ridge and the hard palate, avoiding the **posterior palatine foramina**, anterior to the anterior palatine foramen. Although in the case of endosteal implant insertion the midline is avoided, when placing a total subperiosteal implant it is routine to sever the vessels that pass from the palate into the anterior palatine foramen, because avoiding this area is not possible. Severing the nerves that pass into the anterior palatine foramen will result in a minor degree of paresthesia on the palate, which usually goes unnoticed by the patient. The vessels that enter the foramen drain the palate. When they are severed, collateral drainage is quickly established. Distally, main bearing struts pass behind the tuberosity if there is sufficient available bone. Connecting struts have the same function as in the mandible, and are located accordingly, in the most resorbed areas of the alveolar ridges as close to each cuspid and the distal of each first molar area as possible (Fig. 3-24). These and other design considerations are discussed in detail in Chapter 14.



FIG. 3-24 ■ Maxillary total subperiosteal implant design.

Available Bone Boundaries for Endodontic Stabilizer Implants

The endodontic stabilizer implant has the effect of lengthening the root of an existing natural tooth that has lost some of its bone support (Fig. 3-25). Available bone for this modality is considered to be the volume of bone beyond the apex of the tooth root. First, one must determine whether the tooth is likely to have a favorable prognosis after stabilization. Endodontic stabilization is not meant to save otherwise hopeless teeth. If there is sufficient residual bone around the root, such that the tooth could be saved with conventional treatment, the use of an endodontic stabilizer may be beneficial to strengthen the tooth to improve its prognosis or its ability to act as a successful abutment for a prosthesis. To further enhance the strength of the tooth, it can be splinted to other teeth. Using an endodontic stabilizer increases the crown-root ratio, and further improves the prognosis of the tooth.

In most cases, an endodontic stabilizer cannot be used in the posterior of the mandible, because from the second premolar distally, the roof of the alveolar canal is directly below the apices of the teeth (Fig. 3-26). The use of an endodontic stabilizer in this area puts the patient at risk for paresthesia and therefore should be avoided. A minimum of 5 mm of available bone beyond the apex of the tooth root is required to favorably influence the prognosis of the tooth. Thus, in the mandible, the first premolar and all the teeth anterior to it are good candidates for endodontic stabilization.

In the maxilla, available bone for endodontic stabilization is limited by the floor of the nasal cavity (Fig. 3-27). Anteriorly, there usually are at least 5 mm of bone between the apex of the tooth root and the nasal cavity, permitting placement of an endodontic stabilizer. The teeth most commonly treated in the maxilla are the centrals, laterals, and cuspids. The lingual root of the first premolar is also a candidate, except in rare cases in which it is encroached upon by the anterior extent of the sinus. The axis of the lingual root almost always will guide the stabilizer into abundant available bone. The second premolar in the maxilla also can be treated, depending on the anterior ex-

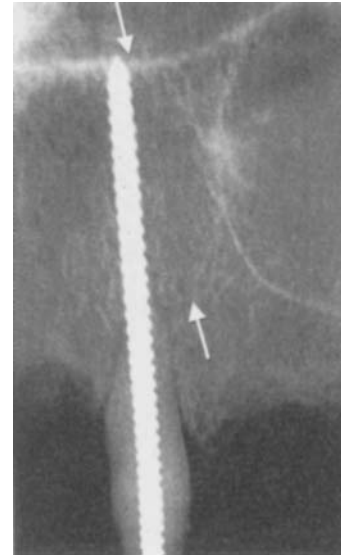


FIG. 3-25 ■ Endodontic stabilizer passing into available bone beyond apex. Note compromised bone support around root.



FIG. 3-26 ■ Relationships of root apices to available bone anterior and posterior to mental foramen.



FIG. 3-27 ■ Depth of alveolar ridge from crest to nasal cavity.

tent of the sinus as evaluated radiographically. Distally, the tooth roots often extend within the sinus and are only covered by a thin layer of bone. Thus, in the sinus area the endodontic stabilizer cannot be used.

It also is possible to create the functional equivalent of an additional natural tooth root using an endodontic sta-

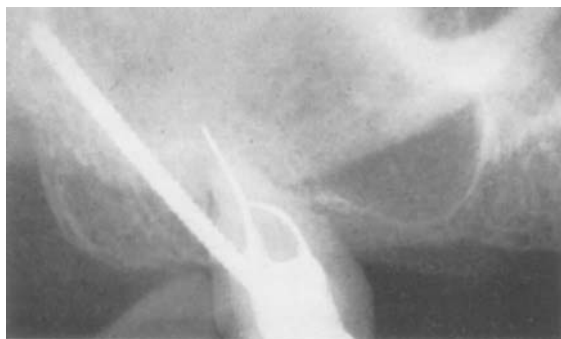


FIG. 3-28 ■ Additional tooth root equivalent created in tuberosity using endodontic stabilizer.

bilizer (Fig. 3-28). This is an advanced procedure that is not considered mainstream. In such cases, the stabilizer perforates an existing root at a depth at least 2 mm below the level of surrounding bone and passes into targeted available bone. In such cases, precise quantification of available bone using the same considerations and boundaries as for mainstream endodontic stabilization is essential.

QUALITY OF BONE

Quality of healthy bone presented by the patient is one of the most widely considered concepts in implant dentistry. One school of thought proposes that the density of bone is of prime importance for implant selection⁸⁻¹⁰ and holds that some implant configurations and surface textures are appropriate for bone of low quality (the least dense bone), whereas other configurations and textures are appropriate for bone of high quality (the densest bone). This concept may be scientifically untenable, for two reasons (see Controversy box).

CONTROVERSY

Quality of Bone

Evaluation of quality of bone is considered to be a benefit by some researchers, whereas others point out that the quality of bone improves after implantation because the inserted implant calls forth new trabeculation, which mitigates the potential importance of preimplantation bone quality. In mainstream cases, evaluation of preimplantation bone quality does not bear upon diagnosis and treatment planning.

First, the idea of using one implant for low-quality bone and another for high-quality bone leads to the following question: Why not use the best implant in all cases, regardless of bone quality? Presumably, if the implant intended for use in lower-quality bone has a greater margin for safety than the one intended for use with higher-quality bone, why not use the implant with the greatest margin of safety every time?



FIG. 3-29 ■ New trabeculation surrounding inserted implant in function. Note lack of trabeculation in areas not in proximity to implant.

The quality of available bone preimplantation is not the quality that the bone will exhibit postimplantation. Putting the alveolar ridge back into function arrests its resorption. Implantation induces the formation of new trabecular bone during healing. When the implant is put into function, this new bone reorganizes. The **trabeculae** realign themselves in direct response to the direction, magnitude, character, and duration of the applied forces to best absorb them within the physiologic limits of health.² Thus, some of the “worst” bone in terms of preimplantation density, such as that often found in the tuberosity of the maxilla, can become some of the “best” bone in function.

So what does preimplantation bone quality really represent? The answer is unclear. Some reports have suggested that preimplantation quality influences prognosis, and others have suggested that it does not.¹¹ However, we can say with certainty that the ability to predict the quality of postimplantation bone with the implant in function is far more relevant and important than evaluating preimplantation quality, which aside from being of questionable diagnostic value is also difficult to perform. It requires complex and costly radiographic procedures. The insertion of one endosteal implant within the residual alveolar ridge calls forth the formation of substantial new bone, in response to function (Fig. 3-29). This bone was not present before the insertion of the implant. It is essentially this reorganized bone following healing and early function that will support the implant long-term.

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4 Implant Materials, Design, and Fabrication

RELATIONSHIPS AMONG AVAILABLE BONE, IMPLANT MODALITY, AND IMPLANT DESIGN

To understand the design considerations in the fabrication of dental implants, it is important to remember that available bone is the prime determining factor for the selection of the ideal implant modality and configuration.

Upon selecting the modality that fits the available bone of the case, or in **overlap cases**, the optimal modality based on clinical considerations, the system and configuration of implant are selected based on the volume and shape of the host bone site (Fig. 4-1). The optimal implant configuration takes the best advantage of the host site, allowing it to withstand the greatest functional load and provide long-term function in health. To facilitate choosing the optimal configuration, root forms, smooth or threaded, parallel-sided or tapered, are supplied in various diameters and depths, and plate/blade forms are supplied tapered or parallel-sided in various lengths, depths, and widths, and in many instances in asymmetrical configurations to place as much available bone as possible into function. Subperiosteal implants are custom-designed to take every advantage of the available bone. Thus, there is an inseparable relationship between available bone and the choice of implant configuration.

RELATIONSHIP BETWEEN BIOMATERIAL AND IMPLANT CONFIGURATION

Any material intended for use in the fabrication of a dental implant must meet two basic criteria. First, the material must be chemically and biologically compatible with living tissue. That is, it must be biocompatible. Second, the material must allow the implant design to be biofunctional with regard to force transfer. The biocompatible material must exhibit properties that enable it to be shaped into a configuration that takes optimal advantage of the available bone for implantation, while maintaining physical properties that meet the specific force requirements of a functioning implant. The term *configuration* as applied herein means not only the shape and size of the

implant but also the topography and material of the **implant interface**. The optimal configuration of a biofunctional implant permits the maximum amount of occlusal force to be transmitted to the investing tissues within physiologic limits of health, thereby providing the greatest margin of safety in a given amount of available bone presented by a patient.

Biocompatibility and **biofunctionability** are the basic considerations in any discussion of **biomaterial** selection for dental implant fabrication. If a material falls short in either of these regards, it is not suitable for implant fabrication. It is sometimes said that one material is “more biocompatible” than another. This is misleading, although tissue reactions may differ. Few studies have shown variation in success or survival rates of two endosteal implants of identical configuration and inserted according to the same protocol, but fabricated of two different biocompatible materials.^{1,2} Additional studies of this type are needed.

To successfully place a healed edentulous alveolar ridge back into function, an endosteal implant must be inserted within bone between and, when possible, partially contacting the cortical plates. After implantation, new trabeculation invests the implant.

The use of an inappropriate biomaterial can compromise design in two ways. First, optimal use of available bone can be compromised by use of a mechanically weak biomaterial. Second, treatment protocol requirements necessitated by the use of certain biomaterials may inhibit the use of a more ideal configuration design. These two considerations are intimately related. For example, an undesirable mechanical property of a biomaterial, such as brittleness, can dictate implant design. This is the case with certain ceramics and carbons. Although they are biocompatible, their brittleness and lack of strength necessitate that larger implant configurations be designed. The required size of a ceramic or carbon implant that has sufficient strength to avoid a high incidence of fracture in function is so large that such implants require a volume and dimension of available bone that is only observed in a small percentage of edentulous alveolar ridges (Fig. 4-2). Most properly fabricated biocompatible metals in use today are strong enough to withstand anticipated forces,

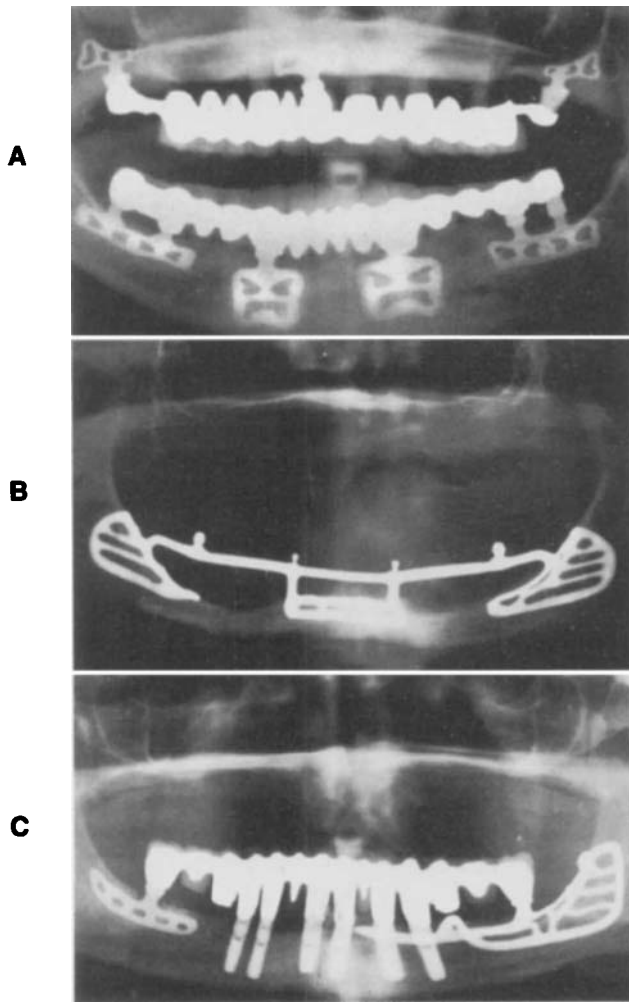


FIG. 4-1 ■ Variations in anatomy of available bone determined the use of plate/blade forms (A), a subperiosteal implant (B), and a combination of root forms, a plate/blade form, and a unilateral subperiosteal implant (C). (B, Courtesy Jerry Soderstrom, Rapid City, SD; C, Courtesy Walter Knouse, Lumberville, Pa.)

even in configurations that are relatively thin bucco/labio-lingually (Fig. 4-3) or shallow in depth (Fig. 4-4), to accommodate most edentulous alveolar ridges.

In the case of root form implants, requirements related to the treatment protocol rather than volume of available bone often influence implant configuration. Root forms that are intended to be submerged or semi-submerged to achieve osteointegration cannot have an abutment or post protruding into the oral cavity during healing. The abutment is attached to the implant after healing, which requires that the implant have an **internal receptor** along its central axis (Fig. 4-5). This internal receptor requires sufficient outer-wall thickness of the implant body to withstand functional loading, which increases the bucco/labio-lingual width of the implant, limiting its application because many patients present with insufficient available bone width. Hence, bone enhancement procedures such as substantial **augmentation**, **ridge expansion** (Fig. 4-6), and **nerve repositioning** can become nec-



FIG. 4-2 ■ Vitreous carbon implant.



FIG. 4-3 ■ Ten-year postoperative radiograph of 1.35-mm-width plate/blade forms.

essary to accommodate the dimensions of the implant. In theory, an implant designed to follow the semi-submerged healing protocol could feature a post integral with the implant body for the attachment of a healing collar and subsequently an abutment, rather than an internal receptor within the body of the implant. This would decrease the diameter of a root form implant and broaden its applicability in narrow ridges. Two-stage plate/blade form implants designed for osteointegration feature such a post and therefore are able to heal afunctionally in configurations of considerably thinner bucco/labio-lingual width (Fig. 4-7). In the case of subperiosteal implants, research has not yet shown that the choice of biomaterial significantly influences implant design. Because subperiosteal implants are custom-made, they are cast, usually from a cobalt-chromium-molybdenum alloy (ASTM F-75)³ such as **Vitallium**, or sometimes from **titanium**. The anatomy of the external surface of basal bone is the primary factor that influences implant design.

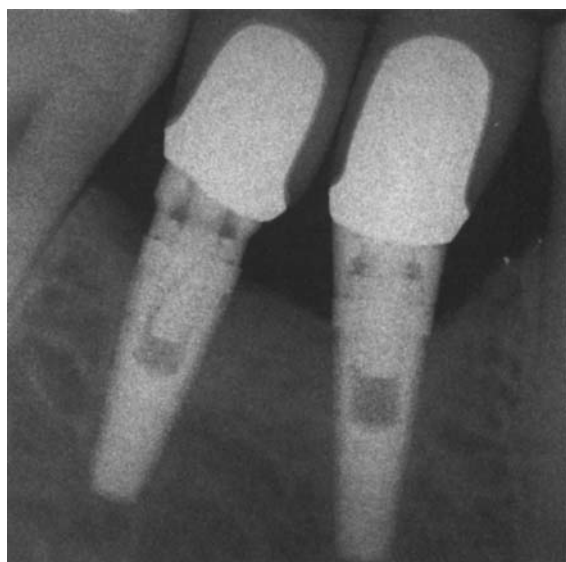


FIG. 4-4 ■ Root form implants with diffusion-bonded micro-sphere interface in relatively shallow available bone.

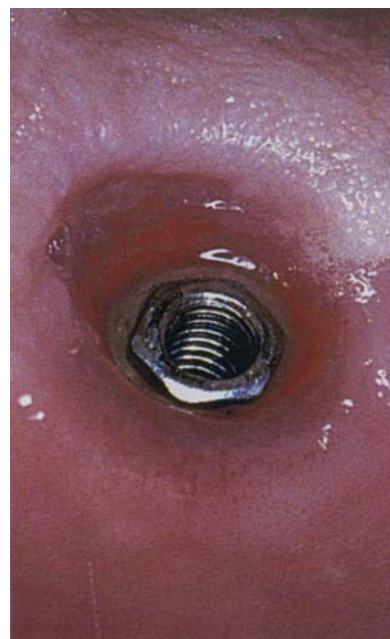


FIG. 4-5 ■ Internal receptor of root form implant for component attachment.

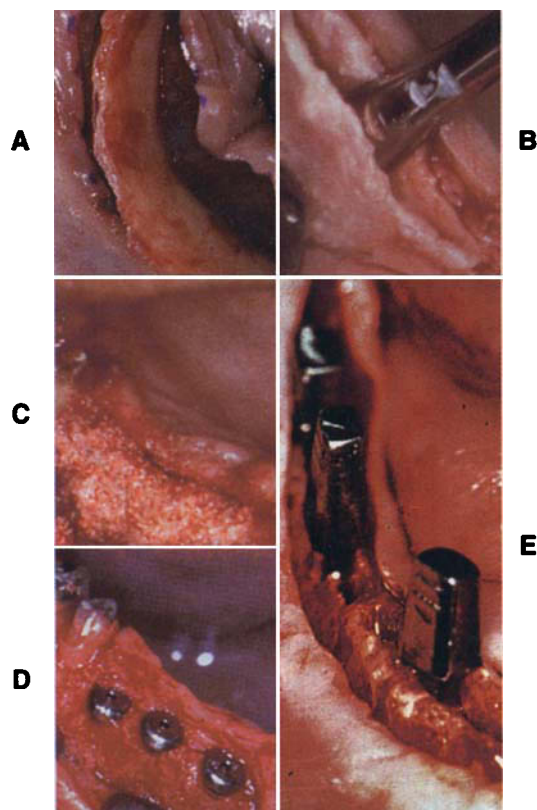


FIG. 4-6 ■ Steps in ridge width expansion protocol to provide adequate bone for root form insertion. A narrow ridge (A) is widened with osteotomes (B), then augmented with alloplast (C), before root form insertion (D). Compare narrow ridge (E) at time of 1.35-mm-wide plate/blade form insertion with no augmentation required. (A, B, C, and D, Courtesy Maurice Valen, New York, NY.)

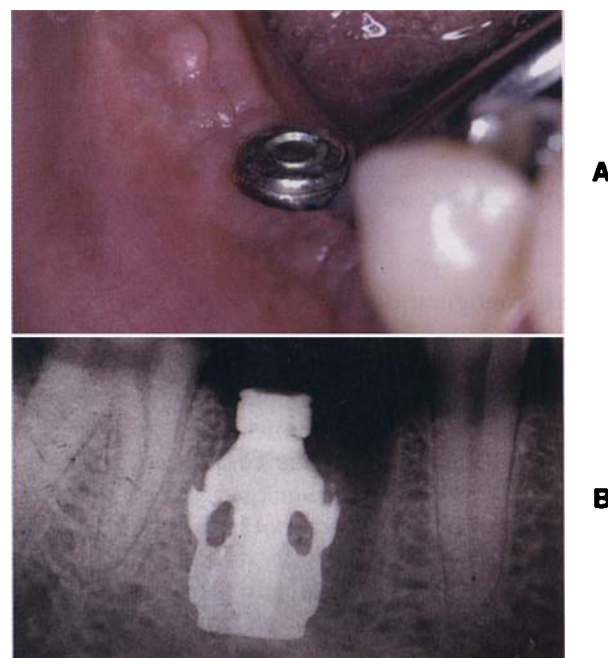


FIG. 4-7 ■ Intraoral view (A) and radiograph (B) of two-stage plate/blade form with healing collar inserted within recent molar extraction site.

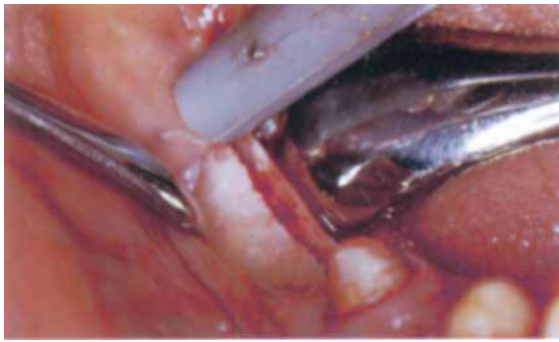


FIG. 4-8 ■ Thin, atrophic ridge suitable for plate/blade form implant. Note minimal bone buccal and lingual to osteotomy.



FIG. 4-9 ■ Optimized metallurgy allows bending of implant body to follow arch curvature.

One advantage of using a biocompatible metal is that its high strength per unit volume ratio allows for the use of smaller configurations, which permits insertion in a wider range of available bone dimensions. Plate/blade form implants, for example, which are generally fabricated of titanium, usually are only 1.2-1.35 mm in bucco/labio-lingual width. Therefore, one can place a plate/blade implant within the available bone width of most edentulous alveolar ridges (Fig. 4-8). In addition, metals exhibit malleability. When metallurgic conditions are optimized, an abutment contiguous with the implant body can be bent to provide intraoral parallelism, and the body of a plate/blade form implant can be bent at the time of insertion to better follow the curvature of healed ridges (Fig. 4-9). Because the anatomy of available bone is so variable, and often the volume so minimal in cases of partial or total edentulism, biocompatible metals have always been and will most assuredly remain the most used, flexible, and dependable of dental implant materials.

BIOCOMPATIBILITY

Key factors that influence the benefits and maintenance of biocompatibility are shown in Box 4-1.

Definition

The term *biocompatibility* has been defined as “the ability of an implanted material to undergo only a minimal amount of deterioration during service, to produce only a minimal change in the body environment, and to function satisfac-

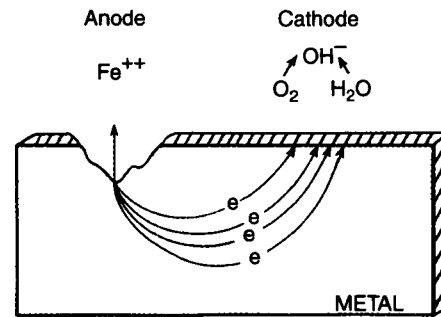


FIG. 4-10 ■ Corrosion reactions on metal surface in body tissue/fluids. (From McKinney RV, Lemons JE, editors: *The dental implant*, Littleton, Mass, 1985, PSG Publishing.)

BOX 4-1 ■ KEY FACTORS THAT INFLUENCE THE BENEFITS AND MAINTENANCE OF BIOCOMPATIBILITY

- Corrosion resistance
- Cytotoxicity of corrosion products
- Metal contamination

torily in every other respect.”⁴ More recently, this definition was refined to be “the ability of a material to perform with an appropriate host response in a specific application.”⁵ This book favors the following definition: “the capacity of a material to exist in harmony with the surrounding biologic environment; not having toxic or injurious effects on biologic functions.”

The compatibility of a metal with its host environment depends on its resistance to biodegradation and on the degree of **cytotoxicity** of its products of **corrosion**. Both of these factors must be investigated to evaluate biocompatibility.⁶

Corrosion Resistance

Corrosion may be defined as the loss of metallic ions from the surface of a metal to the surrounding environment. There are three basic types of corrosion: general, pitting, and crevice.⁷

In the simplest case, *general corrosion*, a metal is immersed in an electrolyte solution. Positively charged ions from the metal are transferred to the liquid electrolyte, and the metal transports the negatively charged electrons (Fig. 4-10). This migration continues until the potential difference or environmental conditions between the metal and the electrolyte are great enough to prevent more ions from entering solution or electrons from being transferred, at which point equilibrium is achieved. This description relates to laboratory conditions and, of course, is not as simple for *in vivo* corrosion phenomena.

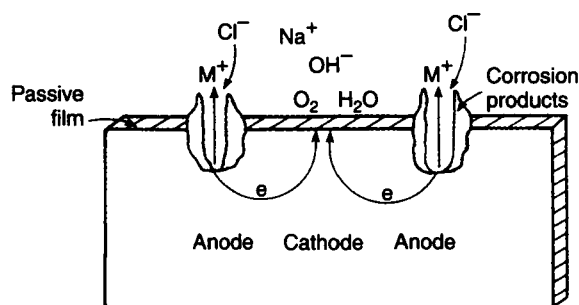


FIG. 4-11 ■ Localized pitting reactions on implant interface.
(From McKinney RV, Lemons JE, editors: *The dental implant*, Littleton, Mass, 1985, PSG Publishing.)

If the metal is non-noble, the number of ions that pass into solution, and hence the degree of metallic corrosion, may be of greater magnitude. In the case of a noble metal, fewer ions enter solution, the electron transfer in the metal is minimal, and little corrosion occurs. Biomaterials must approach the characteristics of noble metals if they are to be successfully employed. Even when they do, if proper metallurgic surface conditions are not maintained, the degree of corrosion may increase.

For example, consider an implant with a small **surface pit**, in a salt solution (Fig. 4-11). Such an implant exhibits two different surface conditions. There can be enhanced corrosion within the pit, as well as corrosion along the overall surface within the aqueous environment. When the metal near the pit dissolves, or loses positive ions from its surface, the associated negative charge from the liberated electrons must be dissipated through the metal of the implant. The metallic surface reaction most often includes elements in the tissue environment such as oxygen. Depending on the rates of the different reactions and the relative "active" surface areas, driving potentials and relative corrosion rates can be greatly influenced. A further enhancement of corrosion can also be associated with an excess of positive ions in the pit, which can cause a migration of negative chloride ions to this site from the solution. They may combine to form metallic chlorides (MCl) in concentrations high enough to alter local pH, which can further stimulate local corrosion. This type of corrosion can proceed very rapidly, actively attacking metallic implants if proper material and surface conditions do not exist. This corrosion type is called *pitting corrosion*.

The local environment around a screw to bone-plate interface or an implant device where an overlay or composite type surface exists on a metallic **substrate** may provide opportunities for *crevice corrosion* (Fig. 4-12). Like pitting corrosion, crevice corrosion occurs in a narrow region, in the case of the screw to bone-plate interface between two metallic surfaces in close proximity. In a tissue/fluids environment in minimal space, little or no oxygen may be present in the crevice. When metallic ions dissolve, they can create a positively charged local environment in the crevice. Negatively charged free chloride ions can combine with

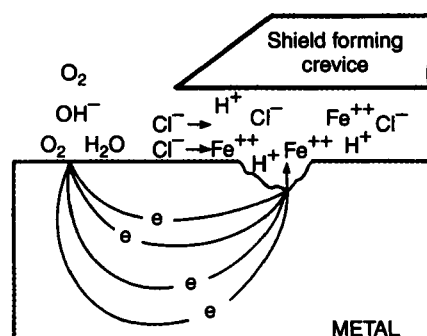


FIG. 4-12 ■ Crevice corrosion in presence of partial shielding.
(From McKinney RV, Lemons JE, editors: *The dental implant*, Littleton, Mass, 1985, PSG Publishing.)

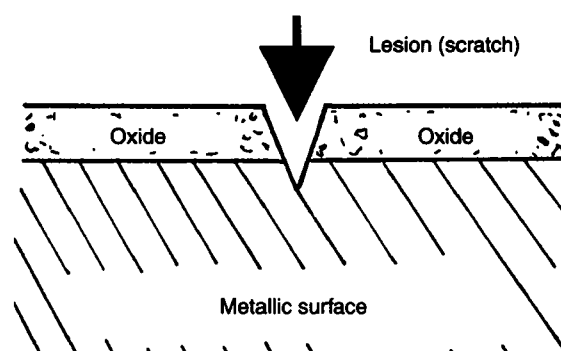


FIG. 4-13 ■ Scratched, passivated (oxidized) metallic implant surface. (From Lemons JE: *J Oral Implantol* 8:362, 1977.)

metallic ions to form new compounds, which may then dissociate into an insoluble hydroxide and acidic condition. This circumstance can accelerate migration of ions to the crevice, further enhancing corrosion.

Thus, the selection of metals and alloys for biomaterials depends on an understanding of corrosion and biocorrosion phenomena.⁸ All metals ionize to some extent, normally decreasing with increasing neutrality of the metallic nobility solution of the environment. Titanium, a metal of choice in oral implantology, is composed of a single-phase (homogenous) metallurgic structure in which the microscopic grains have uniform chemical composition and electrochemical potential. The surface of the metal is covered by a thin, electrochemically stable, tenacious oxide film under normal physiologic conditions. The oxidized surface of titanium exhibits electrochemical characteristics comparable to those of noble metals and will not ionize to any significant degree under normal static conditions.

This passivated (oxidized) surface on titanium is therefore fundamental to limiting corrosion. If the surface is scratched during implant insertion, a localized pathway through the passivated surface is produced that can enhance conditions for metallic corrosion (Fig. 4-13). However, *in vivo*, this pathway reoxidizes (repassivates) almost instantly with exposure to air or oxygenated tissue fluids, a significant advantage that helps to make it more impervious to most types of corrosion. Surgical steels are suscep-

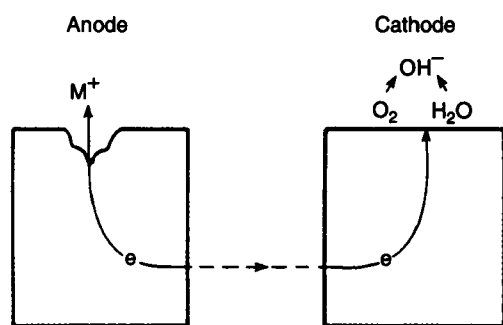


FIG. 4-14 ■ Galvanic corrosion with implant metals. (From McKinney RV, Lemons JE, editors: *The dental implant*, Littleton, Mass, 1985, PSG Publishing.)

tible to pitting and crevice types of corrosion, and do not reoxidize (repassivate) spontaneously. The titanium oxide film resists attack by most oxidizing solutions, particularly those containing chloride ions. Titanium also exhibits outstanding resistance to pitting, crevice, and stress corrosion in both acidic and alkaline aqueous environments. Thus, except in the most exceptional conditions, titanium's resistance to corrosion is extraordinarily high, higher than most known metallic biomaterials.⁹ In addition, its mechanical characteristics, when optimally formed, are excellent for implant devices.

Cytotoxicity of Products of Corrosion

When properly manufactured and used as a biomaterial, titanium undergoes only a minimal amount of biochemical deterioration during service. Because titanium corrodes to such a limited degree, minimal concentrations of titanium are found in the environment surrounding biofunctional dental implants.¹⁰ This small amount produces minimal **toxicity**. Tissue tolerance of titanium and its oxide compounds has been tested.¹¹ Soft tissues and bone implanted with titanium reveal minimal reaction to implantation. The best demonstration of titanium's innocuousness is the fact that it has been widely used for implantation since approximately 1960, and very few titanium dental implants have been removed for reasons of static corrosion and associated tissue interactions.¹²⁻¹⁴

Metal Contamination

Titanium implants can be contaminated by contacting dissimilar metals or alloys. When they are, debris from the dissimilar (e.g., steel) base metal can embed in the implant surface and corrode to form compounds that cause foreign-body reactions in the surrounding tissues. In addition, two different metals in a saline solution, such as a body fluid, may result in a localized difference of electro-mechanical potential that interferes with normal physiologic processes and may also cause accelerated galvanic corrosion (Fig. 4-14). Therefore, it is important that instruments that contact a titanium implant during insertion procedures either be solid titanium, titanium-tipped,

BOX 4-2 ■ IMPORTANT MECHANICAL PROPERTIES OF BIOMATERIALS USED FOR DENTAL IMPLANT FABRICATION

Modulus of elasticity
Tensile strength
Compressive strength
Elongation
Metallurgy

or treated to prevent metallic transfer.⁷ Furthermore, during storage, sterilization, and surgical setup, no other type of metal type should contact the implant or the titanium insertion instruments.¹⁵

MATERIALS

Important mechanical properties of biomaterials that must be considered in dental implant fabrication are shown in Box 4-2.

Properties

For any given configuration of endosteal implant, there is a theoretical "most suited" biomaterial. Listings of physical properties of materials are not useful unless they are related to the physiologic implications of the biomechanics involved. For example, almost always, the **modulus of elasticity** of an implant material should be as similar to that of the bone into which it is implanted as possible.¹⁶ Metals promoted as being stronger should be evaluated mechanically, and in terms of physiologic benefit, within the context of the bone into which implantation is intended.

Modulus of Elasticity and Tensile/Compressive Forces. An important property of any biocompatible material is its modulus of elasticity (E), which represents elastic response to mechanical stress. The forces (F) and stresses within bone that result from loading an implant balance the effect of the externally applied forces of occlusion or muscle action.¹⁷ These forces may establish a condition of **static equilibrium**, or not. When these forces are not in equilibrium, the implant and bone deform or undergo mechanical strain.¹⁸ In **elastic deformation**, the implant and bone regain their original dimensions after the removal of force. For example, if an endosteal implant in function is flexed as a result of functional loading, it returns to its original shape after removal of the applied force. In **plastic deformation**, the original dimension is altered permanently after the removal of the applied force. An example of plastic deformation is when the **neck** of a coined endosteal plate/blade form implant is bent to achieve parallelism for prosthodontic restoration. In this case, the properties of the material are such that a desired

extent of permanent change of original dimension can be achieved, while maintaining metallurgic and clinical integrity. Brittle materials do not deform plastically as increasing force is applied. Instead, they fracture when their strength limit is reached. Examples of brittle materials that can be fractured during insertion and postinsertion function are single and polycrystalline ceramics, carbons, and some coatings of metals, ceramics, and carbons.

Tensile or compressive forces (stresses) applied to a biomaterial or bone cause a change of dimension (**strain**) that is proportional to the elastic modulus. The physiologic importance of the modulus of elasticity of a biomaterial is in part related to this change in dimension (strain) compared with the change of dimension (strain) of the bone into which it is integrated. The magnitudes of the moduli of elasticity can provide a direct measure of the degree of relative movement at the interface that can be expected, since both the bone and the implant deform (strain) as a result of forces applied to either one. Physiologically, this relative movement in part determines the health or pathologic state of interface components and influences the surrounding tissue integration.¹⁶

TABLE 4-1 BASIC MECHANICAL TERMS

Symbol	Meaning
E	Modulus of elasticity (elastic modulus, also Young's modulus)
σ	Mechanical stress (tensile [T], compressive [C], or shear [S], acting at a right angle [T and C] or parallel [S] to the surface area through which the forces are applied)
F	Force (pounds, newtons, etc.)
A	Area (cross-sectional area perpendicular to the direction of force, or the area over which the force is applied)
ϵ	Strain (change of length of a material as a result of applied force, divided by original length)
Δl	Change of length
l_0	Original length

To demonstrate how this applies to endosteal dental implants, a review of some basic mechanics is in order. The symbols in Table 4-1 will be used. Some of the basic formulas of mechanics are as follows:

$$\text{Stress } (\sigma) = \text{Force } (F) / \text{Area } (A)$$

$$\text{Strain } (\epsilon) = \text{Change of length } (\Delta l) / \text{Original length } (l_0)$$

$$\text{Modulus of elasticity } (E) = \text{Stress } (\sigma) / \text{Strain } (\epsilon)$$

Fig. 4-15 illustrates the classic stress/strain diagram from which one may calculate the modulus of elasticity (E).⁶ Fig. 4-16 illustrates the change of length that occurs as a result of compressive force applied to an implant. In a stress/strain = modulus of elasticity diagram, the relative values of (E) for some common biomaterials are shown in Fig. 4-17.

Table 4-2 shows the mechanical properties of selected tissues, and Table 4-3 shows the mechanical properties of selected implant biomaterials. Various biomaterials exhibit substantial differences in elastic properties, which has an important bearing on physiologic response to function. The (E) of alumina-type ceramics is much higher than that of bone, resulting in greater potential for relative movement at the interface (Fig. 4-18). In function, Δl of ceramics is very little, whereas the relative value of Δl of bone at the same mechanical stress M is higher. Correspondingly, because the (E) values of bone and commercially pure (CP) titanium are about four to five times closer than between bone and ceramics for the same interfacial contact area and mechanical stress, there is substantially less potential for relative movement at the interface between bone and CP titanium. The (E) of CP titanium is also closer than that of Ti6AL4V titanium alloy to the (E) of bone. Although Ti6AL4V titanium alloy may be stronger, for many device applications it is not superior to CP titanium, whose biomechanical properties meet the **engineering** requirements for implant design. Cast cobalt alloys are relatively brittle, and carbon is far too brittle for most usable sizes. Acrylics (PMMA) and **polyethylene (PE)** are too soft and have relatively low **fatigue strength** compared with metals and alloys.

The following example demonstrates the importance of the correct choice of biomaterial in terms of potential relative movement at the implant interface during function. Assume an endosteal implant configuration is identically

TABLE 4-2 MECHANICAL PROPERTIES OF SELECTED TISSUES

Property	Tissue						
	Cortical Bone	Dentin	Enamel	Ligament	Hyaline Cartilage	Collagen	Elastin
Ultimate tensile strength MPa (ksi)	140 (20.3)	40 (5.8)	70 (10.2)	0.03 (0.004)	0.03 (0.004)	0.56 (0.081)	0.01 (0.001)
Compressive strength MPa (ksi)	130 (18.9)	145 (21)	260 (37.7)	—	—	—	—
Modulus of elasticity GPa (ksi x 10 ³)	18 (3)	14 (2)	50 (7.25)	—	—	0.14 (0.02)	0.61 (0.09)
Elongation %	1	0	0	5-160	1.8	—	—

TABLE 4-3 MECHANICAL PROPERTIES OF SELECTED IMPLANT BIOMATERIALS

Biomaterial												
Property	Ti (Wrought)	Ti-Al-V (Wrought)	Co-Cr-Mo (Cast)	Co-Alloy (Wrought)		Fe-Cr-Ni (316L)		Al ₂ O ₃		UHMW Polyethylene	PMMA	PTFE
				Annealed	Cold Worked	Annealed	Cold Worked	Sapphire	Alumina			
Density (g/cc)		4.5	8.3	9.2	9.2	7.9	7.9	1.5-2.0	3.9	0.94	1.2	2.2
Hardness (Vickers)	R _b 100	—	300	240	450	170-200	300-350	—	HV23,000	D65	M60-100	D50-65
YIELD STRENGTH												
MPa	170-485	795-827	490	450	1050	240-300	700-800	—	—	—	—	—
(ksi)	(25-70)	(115-120)	(71)	(62)	(152)	(35-44)	(102-116)	—	—	—	—	—
ULTIMATE TENSILE STRENGTH												
MPa	240-550	860-896	690	950	1540	600-700	1000	350-517	480	21-44	55-85	14-34
(ksi)	(35-80)	(125-130)	(100)	(138)	(223)	(87-102)	(145)	(51-75)	(70)	(3.0-6.4)	(8.0-12.3)	(2-5)
ELASTIC MODULUS												
GPa	96	105-117	200	230	230	200	200	28-34	141	1	2.4-3.3	0.4
(ksi x 10 ³)	(14)	(15-17)	(29)	(34)	(34)	(29)	(29)	(4.0-4.9)	(60)	(0.145)	(0.348-0.479)	(0.058)
ENDURANCE LIMIT (FATIGUE)												
MPa	—	170-240	300	—	240-490	300	230-280	—	—	—	—	—
(ksi x 10 ³)	—	(24.6-35)	(43)	—	(35-71)	(43)	(33.3-40.6)	—	—	—	—	—
Elongation (%)	15-24	10-15	8	30-45	9	35-55	7-22	0	0	400	2-7	200-400

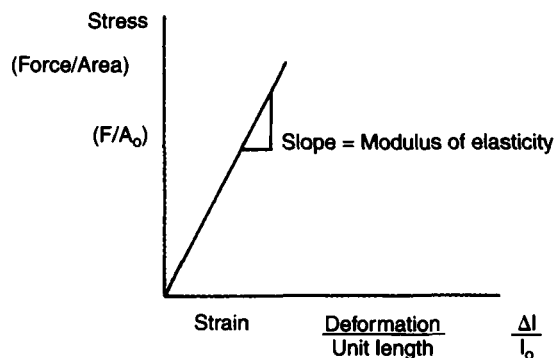


FIG. 4-15 ■ Stress versus strain diagram showing modulus of elasticity. (From Lemons JE, Natiella J: *Dent Clin North Am* 30:3, 1986.)

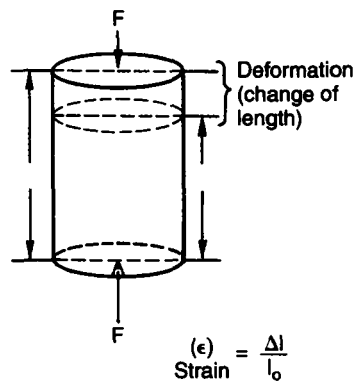


FIG. 4-16 ■ Compressive force applied to a biomaterial or bone, with resulting change of length.

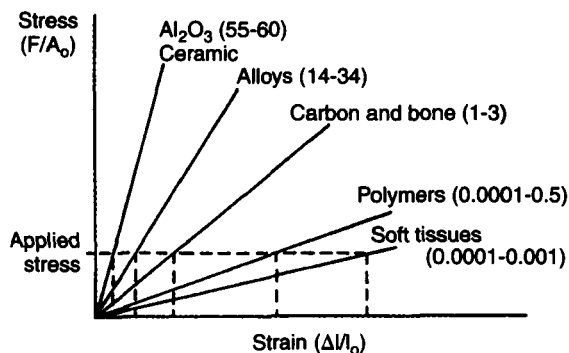


FIG. 4-17 ■ Elastic moduli values for various substances with relative strains per unit applied stress. (From Lemons JE, Natiella J: *Dent Clin North Am* 30:3, 1986.)

uplicated in various acceptable biomaterials, each with a different (E). Assume they are implanted and placed into function, and the planned tissue integration is osteointegration. Assume that the physical properties of each biomaterial are sufficient to withstand in a condition of elas-

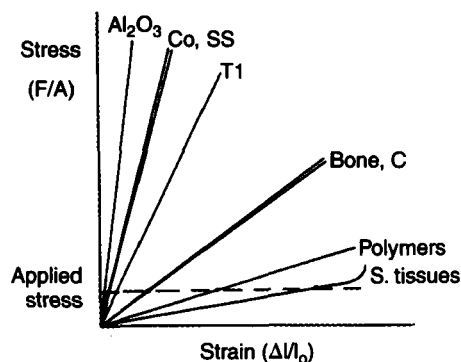


FIG. 4-18 ■ Elastic moduli relationships and an applied interfacial stress. (From McKinney RV, Lemons JE, editors: *The dental implant: clinical and biological response to oral tissues*, Littleton, Mass, 1983, PSG Publishing.)

tic strain all loads (stresses) applied for an indefinite period with no plastic deformation or fracture, and that these identically shaped implants will function under equal loads as abutments supporting identical prostheses in identical patients. Thus, only the biomaterials differ, and there are no other variables.

The direction and magnitude of the force (F) applied to all the implants is the same. The surface area (A) through which the force is applied at a right angle (the functional interface area) is also the same for all of the implants, as they are dimensionally identical. Because (F) and (A) are constant for each implant, the stress (F/A) on each is identical.¹⁹⁻²¹

Because all implants in this example are identical in configuration, the original length (l_0) of each is the same, as shown in Fig. 4-16. The only variable is the change of length (Δl) per unit length that occurs as stresses are applied, because the (E) of each biomaterial is different. Therefore, the greater the difference between the magnitude of the (E) of a chosen biomaterial and the (E) of the bone into which the implant is integrated, the greater the potential for relative movement (essentially **shear**) at the **tissue interface**, increasing the potential for a compromised prognosis.²¹

Based on this and other models and extensive experience, metals have become the most commonly used endosteal implant materials, and especially titanium, which exhibits outstanding resistance to general, pitting, crevice, atmospheric, and **acidic corrosion** (except hydrofluoric). Titanium has the essential qualities for short- and long-term strength in function, including a low incidence of mechanical fracture, resistance to biodegradation over time and function, lack of short- or long-term pathologic responses in the investing tissues, and capacity to form a stable functional interface with host tissues.

In the case of subperiosteal implants, the (E) is not as important a consideration. The envelopment of the implant in the outer layer of the periosteum during healing provides a biomechanical situation more able to accom-

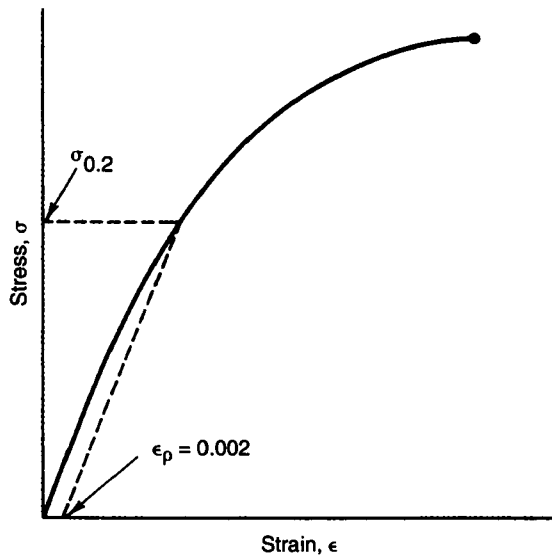


FIG. 4-19 ■ Schematic stress-strain diagram of completely ductile material. (From Hanks RW, editor: *Materials engineering science: an introduction*, example 1.3, p 9, New York, 1970, Harcourt Brace & World.)

moderate relative movement at the interface. The residual ridges and the entire mandible flex in function. In the case of mainstream unilateral subperiosteal implants, the negative effect of relative motion is minimal. For total subperiosteal designs, external bars for clip attachments may cause excessive rigidity. Experience has shown that cutting these at the midline or substituting individual abutments can increase device flexibility.

Metallurgy of Titanium

Proper implant configurations can help effectively control or alter force transmission to remain within physiologic limits of health. The basic metallurgic properties of titanium, particularly its **ductility**, allow it to be strong and malleable, permitting fabrication of optimal dental implant configurations with little compromise. Relatively high strength is required in a prosthetic metal so it can withstand the mechanical forces and stresses placed on it during short- and long-term function without undergoing unintended permanent deformation or fracture (Fig. 4-19). However, a lower toughness specific to deformation is desired so that one can shape the implant during the manufacturing process, and when appropriate bend it to accommodate the anatomic conditions found at the host site. These conditions vary system by system.

Commercially pure (CP) titanium and alloys of titanium exhibit good **elongation** properties. Elongation is directly related to malleability. Low elongation can result in implant fracture during processing or manipulation at the time of insertion. Titanium and its alloys exhibit moderate yield strengths. **Yield strength** relates to the magnitude of stress at which a metallic material shows initial per-

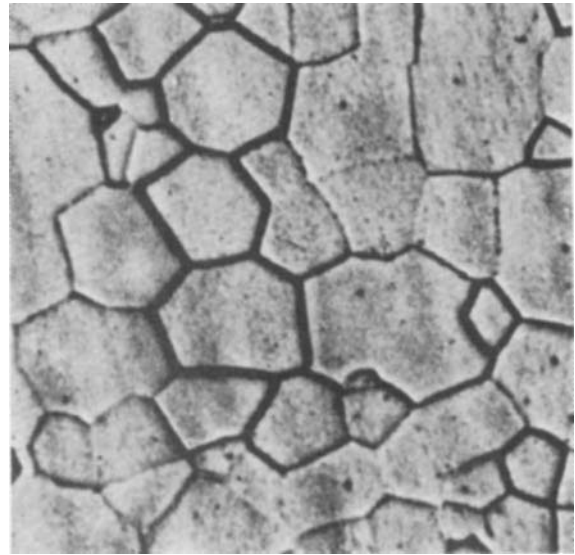


FIG. 4-20 ■ Geometrically precise planned modifications of grain size and orientation resulting from coining.

manent deformation. When the yield strength is exceeded, the shape of the implant is altered. Finally, the tensile strength, the point at which metallic material can fracture in response to an applied load, should be sufficiently high for functional stability of a properly designed dental implant. In general, titanium and its alloys have outstanding strength-to-weight ratios; high rigidity-to-weight ratios; good yield, tensile, and fatigue strength; and adequate toughness for dental implant systems.

The **grain structure** of metals used in implant fabrication is an important consideration. Grains, often called *crystals*, can be of various geometric shapes. They exhibit crystallographic orientations that are a result of their formation, geometric shape, and location within the bulk structure. Metals can be coined or squeezed into desired shapes when sufficient ductility exists such that relative grain rearrangement can occur without disrupting integrity.²² Coining is the process of shaping a metal in a mold or die, especially by stamping. This process affords significant benefits.

Because of the nature of the crystallographic characteristics of polycrystalline forms, it is extremely difficult to coin titanium. In the early 1970s, research by Matarese and Weiss²³ solved this problem, leading to the fabrication of the first coined endosteal dental implants. The coining process permits geometrically precise and planned modifications of grain size and orientation,²⁴ and positions the grains of titanium (Fig. 4-20) within the implant neck and body more nearly parallel to the direction of maximum force, increasing local strength. This reduces metal fatigue over longer-term cyclic loading, and promotes ease and increased safety during insertion adjustments to follow bone anatomy and to establish intraoral parallelism for prosthodontic restoration.

Ti6Al4V, an alloy of titanium (essentially 90% titanium, 6% aluminum, and 4% vanadium) is also commonly used in the fabrication of dental implants. At its interface, titanium oxides form on the titanium grains (crystals), thus rendering the implant as biocompatible as CP titanium from a clinical perspective. There is sufficient information on Ti6Al4V alloys to consider them safe and effective for implant fabrication. A proper coining technique for Ti6Al4V has not yet been developed. Nonetheless, Ti6Al4V can be effectively used for certain dental implants and their components.^{7,25,26}

DESIGN

To fully understand the parameters of endosteal implant design, fundamental information concerning physiology, anatomy, and biomaterials must be considered. The practical application of this information to endosteal dental implant design helps one to understand why and how various endosteal implant configurations do or do not yield acceptable survival rate statistics. Key factors that influence the design of endosteal dental implants are listed in Box 4-3.

The implant must be biocompatible. Any biocompatible material can be formed into a configuration that can be inserted and heal within a fixed amount of available bone, and project into the oral cavity through a pergingival site or be fitted with components for that purpose. If functional forces are placed on the implant within its physiologic limits of health, a normal clinical and histologic picture can be demonstrated. With limited magnitudes of functional loading, one can demonstrate good histology around many implant configurations. Implant design seeks the configuration that will function most efficiently in a limited, fixed amount of available bone, to be able to transmit maximal intraoral functional forces while maintaining the site in health. The ideal configuration should provide an implant abutment with the greatest possible margin of functional safety to enhance the prognosis of the planned prosthetic device. The considerations that follow influence implant design within this context.

Relationship Between Controlled Collagenous Fiber Length and Implant Design

Controlled collagenous tissue fiber length is important to the formation of an **osteostimulatory** peri-implant **ligament** around implants that function in the osteopreservation mode of tissue integration.^{21,27,28} For the purpose of the following discussion, root forms and plate/blade forms will be used as examples for a comparative analysis of the relationships between tissue fiber length, implant design, and the ranges of functional forces in each tissue integration pattern.

Root forms, designed to function in the osteointegration mode of tissue integration, are generally round in cross-section and if threads or fins/plateaus are present,

BOX 4-3 ■ KEY FACTORS THAT INFLUENCE THE DESIGN OF ENDOSTEAL DENTAL IMPLANTS

Biomaterial
Controlled fiber length
Three-dimensional finite element analysis
Surface treatment
Coining
Machining
Casting
Surface etching
Diffusion bonding
Coating

relatively wide both in **major** and **minor diameter**. When sufficient functional forces are applied to a root form implant to cause the formation of a fibrous tissue zone within the alveolus, this fibrous zone cannot exert an adequate osteostimulatory effect, possibly because fibers tangential to the implant body cannot load and deform regional trabeculae. It is hypothesized that fibers of a length required to surround at least 180 degrees of a root form circumference absorb so much functional load by themselves that the trabeculae into which they are inserted cannot be adequately deformed to produce an osteostimulatory effect²¹ (Fig. 4-21). Instead, an unstable biomechanical condition evolves. Probable failure follows, as increasing forces and motions are encountered.

The same results are clinically observed in the case of smooth-surfaced endodontic stabilizers of smaller diameter,²¹ which tend to exhibit a progressively widening soft-tissue zone and failure. This is postulated to result because the fibers enveloping these stabilizers cannot be loaded by the smooth, untextured surface, despite being adequately short to produce an osteostimulatory effect if such loading were possible (Fig. 4-22). In contrast, the collagenous fibers that integrate threaded, textured endodontic stabilizers constitute an osteostimulatory peri-implant ligament, allowing the implant to function in the mode of osteopreservation (Fig. 4-23).

In an animal experiment to test the hypothesis that **collagen** fibers can stress and deform trabeculae of the **cribri-form plate** to help promote bone maintenance by producing an osteostimulatory effect, both smooth and treaded textured endodontic stabilizers of 0.069-inch diameter were inserted between canine mandibular cuspids, allowed to heal, and then placed in function for 18 months. Horizontal sections through the stabilizers and investing tissues showed that smooth stabilizers developed a nonosteostimulatory wide fibrous sheath several times the thickness of the osteostimulatory peri-implant ligaments observed around the threaded textured stabilizers (Fig. 4-24).

A possible exception to the inability of root forms to function long-term in the presence of a fibrous tissue zone

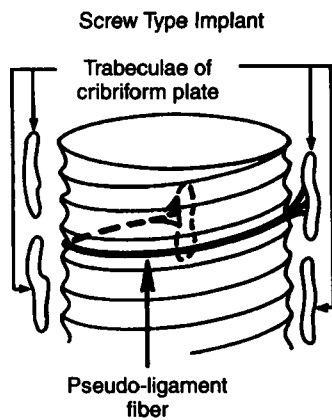


FIG. 4-21 ■ Peri-implant fibers are too long and nonosteostimulatory if they form around a threaded root form implant.

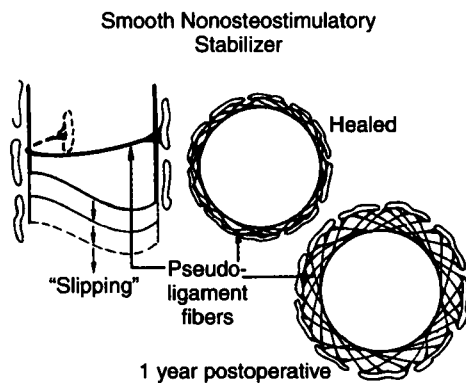


FIG. 4-22 ■ Short but nonosteostimulatory peri-implant fibers around smooth endodontic stabilizer slip and cannot be stressed in function.

is the Innova Endopore root form system,^{29,30} used for treatment of posterior partial edentulism in the teaching case in Chapter 11. These implants have been shown to have the capacity to heal with **osteogenic** peri-implant ligament fibers entwined throughout the porosities of the diffusion-bonded microsphere interface (Fig. 4-25). Thus, these implants may actually function as equivalents of natural tooth roots, in that very short peri-implant ligament-like fibers can entwine the microspheres at the implant interface, and via Sharpey's fibers, deform trabeculae of bone in the implant socket, or cribriform plate, to produce an osteostimulatory effect. It is hoped that continuing research and development of this capacity will result in this system functioning in either the osseointegration or osteopreservation mode of tissue integration, according to the dictates of the case. If so, the benefits of shortened treatment time and use of natural co-abutments in support of a prosthesis will become routinely available for these root forms, as they are now for plate/blade forms.

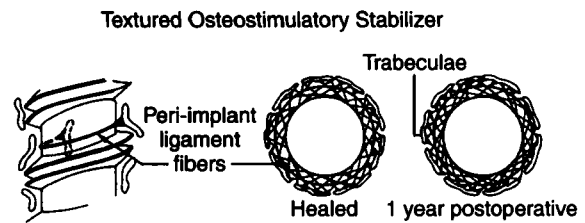


FIG. 4-23 ■ Short osteostimulatory peri-implant fibers around threaded, textured endodontic stabilizer cannot slip and therefore stress trabeculae in cribriform plate.

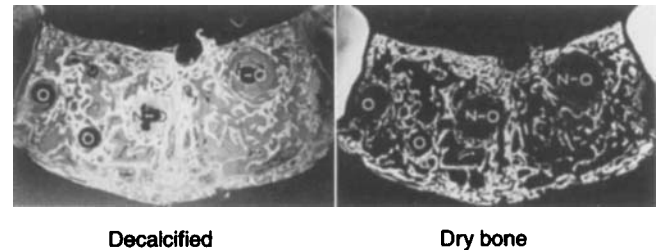


FIG. 4-24 ■ Nonosteostimulatory (N-O) and osteostimulatory (O) peri-implant fibers around smooth and threaded textured endodontic stabilizers, respectively, in decalcified (*left*) and ground bone (*right*) horizontal mandibular histologic sections of anterior mandible.



FIG. 4-25 ■ Implant interface showing diffusion-bonded microspheres with entwined peri-implant collagen fibers throughout the interconnecting porosities. (Courtesy Innova Corp.)

The plate/blade form implant, which is designed to function in either the osseointegration or osteopreservation mode of tissue integration, is generally tapered in cross section and vented to promote stability and enhance vascularity of the dental alveolus. The dimensions of the

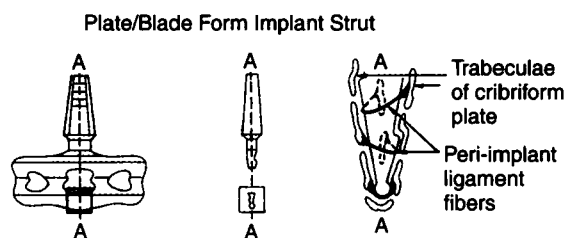


FIG. 4-26 ■ Plate/blade form implant strut. Short osteostimulatory peri-implant fibers stress trabeculae in cribriform plate.

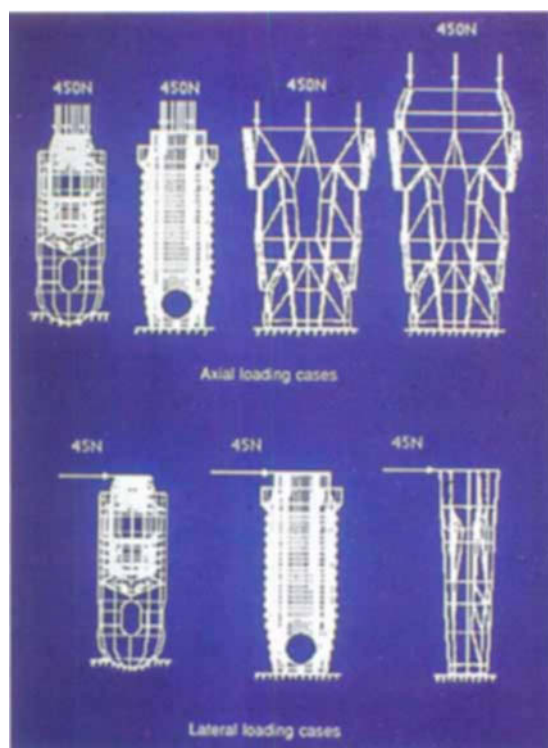


FIG. 4-27 ■ Three-dimensional finite element comparative modeling of axially loaded cases (*above*) and laterally loaded cases (*below*).

struts and vents are balanced between maintaining optimal interface area and optimal fiber length in the peri-implant ligament. The promotion of controlled collagenous tissue fiber length in cases that follow the osteopreservation healing protocol is a prime concern (Fig. 4-26).

Three-Dimensional Finite Element Analysis

It is helpful to understand the nature and value of computer-based three-dimensional **finite element analysis** and how it relates to dental implant analysis and design.³¹⁻³³ A predominant factor limiting long-term implant maintenance is excessive load borne by the abutments supporting a restorative prosthesis. An excellent way to ana-

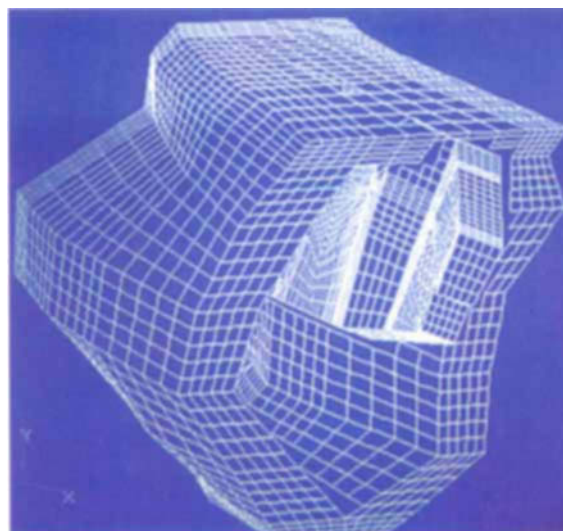


FIG. 4-28 ■ Three-dimensional finite element model with inserted implant.

lyze the effects of load, and to understand how to modify load transfer by improving implant design, is to use three-dimensional finite element analysis. It is also a useful tool for comparative analysis of root form and plate/blade form systems and configurations, which intuitively cannot all have the same range of forces that represent physiologic limits of health (Fig. 4-27). Three-dimensional finite element analysis also allows the analysis and modification of surface texture to improve prognosis.^{34,35}

Computerized models of “living bone,” and implants inserted within it, with and without the interposition of shock-absorbing peri-implant structures, have been constructed to aid in the analysis of implant configuration design.³⁶ A typical model is shown in Fig. 4-28. A finite element is a geometric shape, such as a pyramid, trapezoid, rhomboid, or cube. These elements can be used as building blocks to create a model of anything, such as bone or an implant. One commonly used element shape is the cube. Each cube has eight points, or nodes, and extending from each node are x, y, and z coordinate axes. When viewing a computer model of a finite element system, the x, y, and z axes are displayed to show the perspective from which the total or specific regions of the model are being observed.

In a combined finite element model of an implant placed in bone, stress and strain under conditions of **tension**, compression, and shear can be calculated based on the mechanical properties of each of the materials being modeled.

An implant within bone can be modeled to contain a discontinuous zone for a slip (frictionless) condition, or a continuous zone for a no-slip (adhered) condition at the interface (Fig. 4-29) to act as parameters for calculation to better understand the biomechanical environments of osseointegration and osteopreservation. The implant can be loaded vertically, horizontally, or in any lateral direction, at any magnitude, with a variety of characteristics (steady or in-

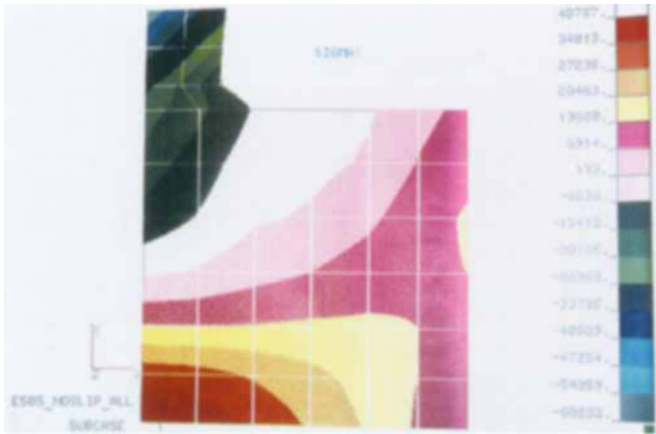


FIG. 4-29 ■ Typical no-slip stress distribution analysis.

termittent, with variables), and for any duration. The stresses and strains that pass through the implant interface and within the implant at every node of every element can be calculated as a function of direction, magnitude, rate, and duration of applied load. Ultimately, modeling bone is more difficult than modeling implant configurations.

These models allow the measurement of forces along the entire implant interface as they pass to the modeled apposing bone or peri-implant ligament, which reacts in an equal and opposite manner. To be useful, computerized results are correlated with histologic and radiographic findings around functioning implants, to understand how clinical functions *in vivo* cause what is theoretically predicted by three-dimensional finite element analysis.

The use of this technique has already generated unique implant designs. As this important discipline evolves, its contribution to the future of implant design will continue to increase in importance. Design improvements will reduce areas of stress concentration, more nearly achieve **stress transfer homogenization** across the interface, and ultimately affect long-term bone maintenance favorably at each point on the implant interface.

FABRICATION

Plate/Blade Form Coining Process

The formation of titanium in the shape and size of a plate/blade form dental implant is challenging. **Cold forging** and coining are desirable forming techniques for some implant configurations because they combine the virtues of high precision and excellent finish. Importantly, they allow for planned and variable grain structure alignments in the various parts of the implant to enhance desired mechanical characteristics. However, titanium is not readily formed. Under very high mechanical stresses, applied slowly, it can be made to “creep” slightly, but its almost crystalline structure is such that a routine attempt to stamp or form it can result in damage rather than plastic deformation. On the other hand, most alternatives to cold forging have associated problems. The grain struc-

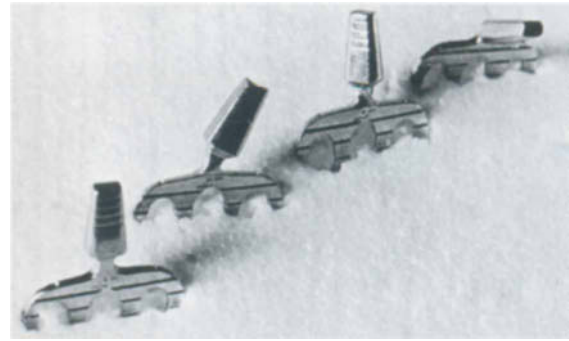


FIG. 4-30 ■ Bending and rotational abutment adjustments on one-stage plate/blade forms made possible by coining titanium.

ture after machining, for example, is the same as that before machining, and far different from that after cold forging. Tool marks can remain on the implant, and machining may result in contamination from tool-based metal transfer.

Following a research project in cold forging medical grades of titanium, a reliable method of coining was developed. Proprietary processing was used to alter the grain structure such that the coined metal exhibited enhanced properties. The grain structure became finer in texture and considerably elongated, which improved workability. For example, plate/blade form implants formed by coining can readily be bent to follow the contour of the arch. The abutments can be bent to different angles or rotated with respect to the implant body for prosthodontic parallelism without clinically significant loss of residual ductility. Following coining, the abutment head can slowly be bent 45 degrees to the buccal, returned to its initial position, then bent 45 degrees to the lingual, returned to its initial position, and then rotated 45 degrees on its vertical axis without fracture²² (Fig. 4-30). This workability of properly coined titanium offers the practitioner a good deal of latitude and safety in adapting plate/blade form implant configurations to solve problems related to prosthodontic parallelism and the vagaries of anatomy sometimes encountered during surgery.

Coining also provides control over surface texture. Controlling the variables associated with the electric discharge method (EDM) of preparation of the coining die permits the design and formation of a specialized interface texture. By incorporation of the negative aspect of the texture into the coining die surfaces, one can impress a desired texture into the surface of the finished implants. Thus, coining provides control over topography, micro-smoothness, and metallurgic purity. The final step in fabrication is surface decontamination, at which time an even “skinning” of a few **microns** of surface is removed. The result is a pure implant interface of titanium oxide, which reforms instantaneously. If an implant is trimmed or bent to fit the available bone anatomy into which it is to be placed, the metal

surface again reoxidizes instantaneously to ensure maintenance of tissue compatibility.

Machining

Machining today's root form implants is both an art and a science. Complex, computerized, multi-head tape milling and grinding equipment is programmed to fabricate, within required tolerances, a large array of implants along with their healing, transfer, and abutment/retention components. The nature of the cutting (milling) and grinding instruments, the speed, the cooling mechanisms, and other influential factors are correlated with the nature and properties of the biomaterial and the configurations being fashioned.

Casting

Subperiosteal implants are always cast. The most common biomaterial used is Vitallium, an alloy of cobalt, chromium, and molybdenum. Variations include titanium or alloys that are cast in inert gas and/or vacuum systems. Practitioners are aware of the constraints placed on this process by the need for accurate passive fit of the finished seated implant. The refractory model, investment material, volatilization of the wax preform, and preparation of the metal (in argon or a vacuum for titanium) for casting are all synchronized and interrelated within a protocol for each material used. Following proper casting, breaking out, cleansing, finishing, polishing, **passivation**, and sterilizing, the custom-made implant is ready for use.

Interface Enhancement

Various dental implant systems have modified interface topography, including impressed textures, diffusion-bonded microspheres, **plasma spray**, various **hydroxyapatite (HA) ceramic** coatings, grit blasted/acid etched surfaces, and others. These have been analyzed related to their claims, benefits, and complications.³⁷ The relative contribution of the implant interface to overall success and long-term investing tissue stability has been considered. This area of investigation has been controversial, and each type of altered surface must be considered separately.

To reduce excessive smoothness following implant fabrication, a variety of etching procedures are sometimes used to alter an interface texture. These can include high-pressure air streams carrying aluminous oxides, acids and other chemical etching procedures, and surface peening with microbeads delivered at high speed. Custom-made subperiosteal implants are commonly utilized surface-etched implants. The interface texture of some root form systems is determined by a combination of controlled grit blasting and acid etching.

Regarding the relationship between dental implant design and interface enhancement, there are two points of view. One school of thought is that the essential elements

for success are the chosen biomaterial and the implant configuration. The resulting biomechanics of functional stress transfer across the implant interface affect the short- and long-term physiology of the investing tissues. Advocates of this position hold that topography at the interface acts as an enhancement, and that some coatings have been promoted as "cures" for problems that may not exist, and may offer little benefit that can be confirmed by valid evidence. In some situations, coatings may even be deleterious. Another school of thought is that the nature of the biomaterial and interface topography are the essential elements of success, and that implant configuration is relatively less important.

Research and experience have indicated that basic biomaterial properties and the configuration of the implant, considered from a biomechanical point of view, are the primary and controlling factors. At the implant/tissue interface, the biochemical response of **osteoconduction**, and possibly in the future **osteinduction**, may help to promote long-term stability of a system. Thus, according to this view, the interface condition becomes an adjunct to overall biofunctionability and is incorporated to enhance the biomechanical response by increasing interface area and in some cases bone ingrowth anchorage.

In the case of the diffusion-bonded microsphere interface of the Innova Endopore system, configurations two thirds the depth of conventional root forms have been shown to perform with comparable safety and effectiveness.³⁸ **Sinus lifts** (subantral augmentation) can often be avoided when there is shallow bone under the sinus, or minimal depth of bone over the mandibular canal can be used for mainstream treatment with root form implants with the diffusion-bonded microsphere interface.

For comparative purposes, various interface enhancements such as **diffusion bonding**, surface coating, and surface impressioning are analyzed as follows, including an overview of their benefits, risks, and complications. In this regard, the importance of data derived from studies that yield valid scientific evidence cannot be overemphasized. Federal devices legislation defines such studies, in part, as well-controlled investigations.³⁹ The most reliable type are **controlled, prospective, longitudinal, randomized, independent** clinical trials. The federal government will not accept as valid scientific evidence, "isolated **case reports**, random experience, reports lacking sufficient details to permit scientific evaluation, and unsubstantiated opinions."

Controlled studies have demonstrated the benefits of the **Tissue-Tac** interface texture of Oratronics plate/blade form implants.²² This Tissue-Tac surface texture has been in use in excess of 30 years in well over 1 million implants. The Nobel Biocare/Steri-Oss root form **fixture** is an example of a standardized interface, and beneficial claims related to tissue integration have been associated with surface irregularities that occur as a result of machining.⁴⁰ Animal and human studies have been conducted in support of the diffusion-bonded microsphere interface of the Innova Endopore System to validate the benefits of bony

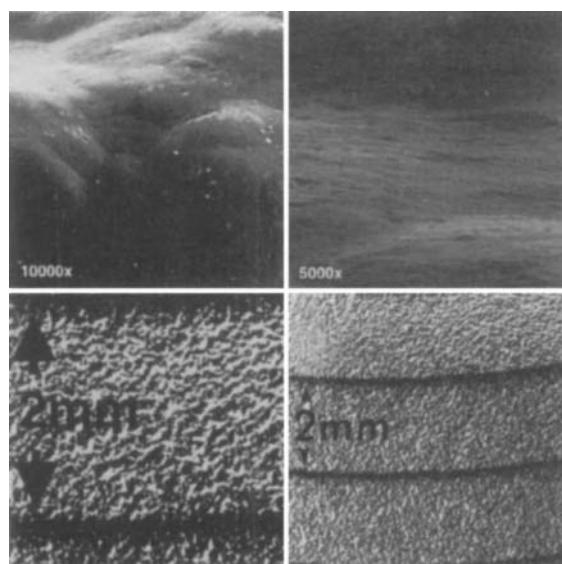


FIG. 4-31 ■ Scanning electron microscopy (*above*) and close-up photography (*below*) of coined titanium Tissue-Tac Interface Texture on plate/blade form implants.

ingrowth within the porosities, and in support of the Frialit Frios Titanium plasma-spray surface, HA plasma surface, and grit-blasted, etched depth structuring.

Impressioning—Tissue-Tac Texture. The purpose of the impressed Tissue-Tac interface is to provide a technique-permissive surface aimed at increasing interface area and reducing biomechanical stress across integrating tissues. The texture is impressed into the interface as part of the coining process during fabrication of the implant. The relatively smooth, undulating topography is similar to the surface texture of natural dental cementum (Fig. 4-31). Studies of the orientation of **fibroblasts** cultured *in vitro* have demonstrated that the interface texture affects cell orientation and is compatible with contiguous development of an osteostimulatory peri-implant ligament.^{41,42} The Tissue-Tac Texture is the result of the first dedicated effort for a planned increase in interface area and greater tissue compatibility through interface surface modification. It has been in successful clinical use since 1970.

Because cell behavior related to implants is influenced by surface topography, beneficial biologic results are promoted by an interface texture.^{30,42} The surface texture on an implant has the potential to specifically influence certain populations of cells and alter their functions. It is therefore postulated that “contact guidance” plays a role in cellular adhesion to smooth undulations.⁴³

The consistent nature and replicability of the Tissue-Tac interface were evaluated with a Surfanalyzer 4000. A high-resolution EPT-01049 (0.0001-inch) stylus was used for surface characterization for direct recording of the surface topography and standard calculations of surface roughness parameters. The profilometric tracings revealed remarkable similarities between tracings taken at different locations

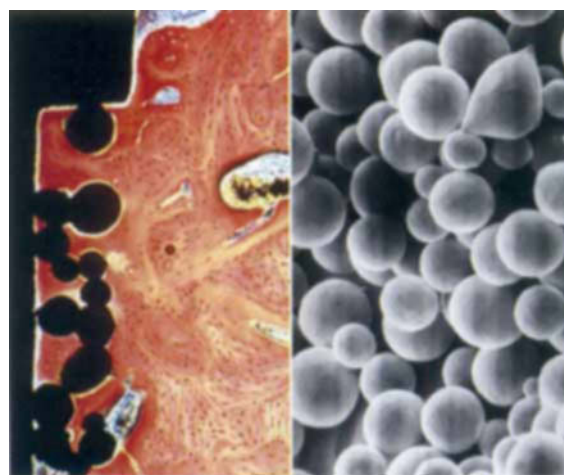


FIG. 4-32 ■ Histology of osteointegration (*left*) and scanning electron microscopy of diffusion-bonded microsphere interface (*right*). (Courtesy Innova Corp.)

on the interface.⁴⁴ Quantitative surface profiles of the implant body section along the mesio-distal (horizontal) and occluso-gingival (vertical) directions showed similar patterns. The profiles of various implants were consistent and correlated with stereomicroscopic examinations and previous scanning electron microscopy (SEM) studies.

The impressed Tissue-Tac interface texture cannot exhibit **delamination**, peel, dissolve, or change over time. Implants with this surface treatment can be handled, sterilized, and resterilized like surgical instruments. Interface contamination is rare, because the surface is smooth and undulating at the ultra-microscopic level. This texture resists attraction or entrapment of **particulate** material such as latex, powder, cotton strands, or gingival epithelium.

Diffusion-Bonded Microsphere Interface. The diffusion-bonded microsphere interface perfected by Innova is achieved through the use of a proprietary process that yields an interface area increase of more than 300%. This reduces stress applied to integrating tissues and substantially increases interface attachment as a result of bony ingrowth.²⁹ Individual microspheres range from 45 to 150 μm in diameter. The final structure contains about 35% volume of uniformly distributed pores of 50 to 250 μm diameter contiguous with the interface, to a depth of 300 μm (Fig. 4-32). Bony ingrowth within the interconnecting porosities provides three-dimensional interlock that offers substantial resistance to torsional and other applied forces.

Diffusion bonding is conducted at 1250° C in a vacuum ($<10^{-5}$ torr) for 1 hour. Unlike plasma flame spray **sintering**, diffusion bonding homogenizes the metallographic structures among the microspheres and their underlying substrate into a relatively strong solid mass that is signifi-

cantly different than that observed between a plasma flame spray coating and its substrate. The 50- to 250- μ m porosities are ideal for promotion of bony ingrowth.

To accurately assess interface area, one must differentiate the real surface/tissue contact area from the geometric interface area of the implant. The real interface area is enhanced by diffusion-bonded microspheres. This is why clinical results demonstrate that configurations with the microsphere interface can be substantially shorter than conventional implants, and offer comparable support.

The diffusion-bonded microsphere interface yields the following real interface areas⁴⁵:

Real Interface Area of Implants with Diffusion-Bonded Interface		
Implant Depth (mm)	Implant Diameter (mm)	Real Interface Area (mm ²)
8	3.5	512
7	4.1	527
9	4.1	640
12	4.1	781
7	5.0	638

The real interface area of a conventional threaded root form is comparatively lower:

Real Interface Area of Conventional Threaded Root Form Implant		
Implant Depth (mm)	Implant Diameter (mm)	Real Interface Area (mm ²)
12	4.0	248

Innova Endopore implants are fabricated of titanium-aluminum-vanadium alloy. The tapered design of the implants promotes elevated levels of fatigue endurance, since the **coronal** portion is wider in diameter than the apical portion. This taper also ensures a tight fit and promotes function coronally to help offset stress shielding along the narrow, smooth crestal band on the implant. This reduces bone resorption that may result from hypofunction. The taper also reduces the incidence of cortical plate bone perforation during osteotomy preparation near anatomic undercut areas and protects adjacent natural tooth roots.⁴

Grit Blasted/Acid Etched Depth Structuring. The micro-retentive, depth-structured Frios implant surface is achieved by grit blasting and acid etching. Depth structuring includes four phases: sandblasting, **etching**, neutralization, and cleaning. The aluminum oxide (Al_2O_3) blastic material provides a defined macro-roughness. Micro-pits are created by etching with mineral acids to further increase interface area (Fig. 4-33).

Coatings. Critical factors specific to coatings are the maintenance of attachment between the coating and its substrate, biocompatibility of the altered substrate, solubility,^{42,46} resistance to fracture and crazing, and technique-sensitivity during the insertion process. Surface coating techniques in dentistry include plasma-sprayed metallic or ceramic, and combinations of both.

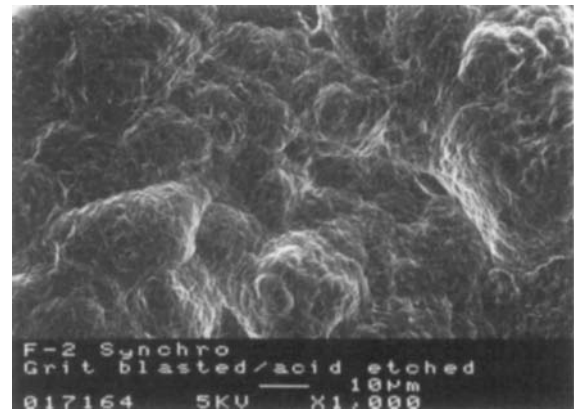


FIG. 4-33 ■ Scanning electron microscopy of grit blasted/acid etched depth structuring. (Courtesy Friadent Corp.)

Practitioners who use coated implants do so to achieve a combination of potential benefits. Research continues to investigate the extent to which each of these benefits is associated with various coatings. The potential benefits are as follows:

- That calcium phosphate coating permits bone to bond with the implant surface
- That HA-coated implants are superior with respect to degree and rate of fixation in bone
- That more supporting bone is present at the HA-coated implant interface, contributing to implant longevity
- That HA-coated implants show better clinical performance than uncoated implants
- That calcium phosphate coatings do not demonstrate in vivo resorption, which would negatively influence the implant interface

Plasma-Sprayed Metal. Friadent is known to process a fine, stable, uniform titanium plasma spray (TPS) interface (Fig. 4-34). In the plasma coating process, titanium is heated within a plasma stream of ionic constituents, with partially molten particulate titanium maintained in the stream. A magnetic coil enables one to direct the stream and “spray” a plasma-based coating onto a surface placed in its path. This is recognized as a technique-sensitive technology. In the presence of a proper vacuum, few contaminants form that could adversely influence coating adherence to the substrate. Achieving predictable uniformity of thickness and **porosity** is desirable.

The next step for some products is an **annealing** treatment. This normalizes the structure across the interface along the substrate and between individual sprayed particles. The process requires exposure at temperatures more than half the melting point of the metal. At this temperature, the metal recrystallizes with resulting grain-size growth, which has the potential to reduce both ductility and strength. Implants subjected to the plasma flame spray process do not permit bending or other adjustments to aid parallelism, since this would fracture the coating.⁴⁷

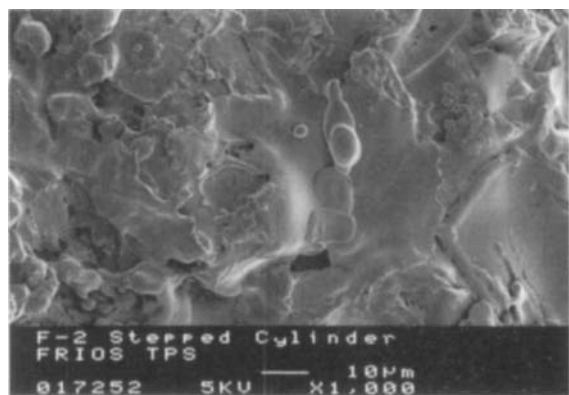


FIG. 4-34 ■ Scanning electron microscopy of plasma-sprayed titanium (TPS). (Courtesy Friadent Corp.)

The practitioner must carefully insert coated implants to avoid contaminating them, for example, with latex or epithelium that can abrade into the interface on contact.

Plasma-Sprayed Hydroxyapatite/Calcium Phosphate. The application of calcium phosphate ceramics as coatings originated in dentistry. Root form, plate/blade form, and subperiosteal implants with substrates of cast cobalt alloys, as well as titanium, have been coated with calcium phosphate ceramic-like compounds. Many were fabricated as porous bioceramics to provide opportunities for tissue ingrowth.⁴⁸ The microstructures often show fused and partially compacted particulate microscopic grains with a variety of isolated microporosities within the coating. Differences in the degree of crystallinity, degree of purity, and influence on implant performance⁴⁹ are a consideration. Higher crystallinity may contribute to stability of the material but may also influence the durability of coating attachment to the implant. Higher crystallinity influences biomechanical and biochemical responses.

Dense and crystalline HA coatings have been difficult to produce. Friadent has been successful in producing uniform results. Most coatings show a gradient structure at the microscopic and macroscopic levels.^{50,51} Studies have also demonstrated that some calcium phosphate ceramics may fracture under cyclic loading conditions when stresses are above fatigue strength limits. Limited data are generally available regarding fatigue and fracture strengths under load. The American Society for Testing and Materials (ASTM) committee F-4 on medical devices has reviewed the need to improve the consistency of characterization.⁴⁶ When mechanical tests have been performed, studies have shown that different methods for tensile, compressive, or push out (shear) tests have not provided valid correlation because of different testing conditions. This has occurred in part because of the high degree of variability in the manufacturing process, and differences with regard to coating type and thickness. Only long-term in vivo clinical trials of identically configured implants, coated with HA and uncoated, including comparisons of long-term survival, can adequately assess long-term effectiveness.

Because of variations in chemical and biomechanical solubility, calcium phosphate compounds have demonstrated various degrees of resorption depending on coating chemistry, crystallinity, density, microstructure, and **host site** environment. If a coating resorbs over time, the ultimate fate and biocompatibility of the exposed altered substrate interface must be analyzed. Reactivity tests conducted on ceramic coatings have demonstrated varying degrees of resorption.⁵²

In cases of clinically functioning implants in which gingival recession exposes the marginal coating, it is not clear what treatment is preferred. In addition, the method for controlling porosity-enhanced pathways of infection along the interface requires clarification, including if and how an implant with this complication can be retained.

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5 Implant Insertion and Healing

HOST SITE

A basic tenet of this book is that the host site chosen for mainstream implant insertion should be close to ideal and that the patient's general health should be sound. In cases in which the host site may not be ideal, one must carefully evaluate exactly what makes it compromised, and how this compromised condition may affect prognosis, to determine whether to proceed with treatment.

Compromised Host Sites

Compromised Ridge Height and Width. Very few clinical presentations of ridge dimensions can be considered compromised for treatment using **multimodal implant dentistry**. Abundant available alveolar bone, severe alveolar resorption down to basal bone, and everything between can undergo mainstream treatment if the modality and configuration are properly selected in accordance with the available bone parameters. Characterizing the dimensions of available bone as compromised in any given case may be a manifestation of focusing on a single modality.

Pushing the limits of any modality by using it in inappropriate available bone dimensions represents compromised treatment.

Compromised Health. Certain health problems or patient habits that are destructive to oral health represent compromised treatment situations. It is important to remember that these patients have the greatest need for treatment. The goal should not be to screen these patients for exclusion but to identify those with special needs and treat them accordingly. These patients need and deserve the benefits of implant dentistry.

One approach to determining whether implant treatment is contraindicated for a patient is comparative. If the compromised patient under consideration required periodontal treatment followed by splinting of natural teeth, what precautions, based on the patient's particular condition, would be taken? Would such treatment be contraindicated? What would be the best approach to required tooth removal for the patient? Approach the patient in the same way for implant dentistry treatment. In this regard, an ally is the patient's physician. Consult with him or her.

Consider the physician's advice regarding the patient's suitability for treatment, and record all relevant information on the treatment record. Cases in which mainstream implant dentistry treatment is contraindicated are uncommon.

A special and relatively common consideration is the heavy smoker. Smokers heal poorly.¹ It has been shown that in addition to nicotine, other byproducts of tobacco smoke cause changes in blood flow in the oral mucosa,² alter polymorphonuclear leukocyte (PMN) function,^{3,4} and decrease vascularity, which leads to compromised healing. Abstinence from smoking is recommended from 2 weeks preinsertion through 6 weeks postinsertion.

Compromised Oral Hygiene. Another special and not uncommon consideration is the patient who has compromised oral hygiene. It may sometimes be wise to refuse or delay treatment until the patient demonstrates, for at least 3 months preinsertion, that he or she is able to achieve ongoing and acceptable oral hygiene. Patients who have poor oral hygiene can be trained for improvement, but with mixed results long-term. Increased frequency of professional prophylaxis is indicated for these patients postoperatively.

As with patients who have compromised general health, one should evaluate fitness to undergo mainstream implant dentistry treatment in the context of hygiene as one would for routine dental procedures such as tooth extraction and periodontal treatment.

Radiation Treatment and Chemotherapy. Less commonly encountered are patients who have undergone radiation treatment and/or chemotherapy. Such patients are considered case by case, in consultation with their physicians, and are not considered mainstream. Some of these patients may require hospital-based treatment, and in some treatment is contraindicated.

In one case treated by the author, a patient who underwent partial resection of the mandible and tongue on the left side followed by irradiation received medical permission to proceed with mainstream plate/blade form treatment in which a distal abutment was placed in the left tuberosity, followed by fabrication of a fixed partial prosthesis with natural co-abutments. The case has been in function for more than 8 years, without complications.

The patient reports substantial improvement in ability to eat and overall satisfaction with the procedure.

FACTORS RELATED TO HEAT PRODUCTION DURING OSTEOTOMY PREPARATION

The amount of heat produced by dental implant osteotomy preparation at different instrument **rotational speeds** and the effects of heat production on the prognosis of implant treatment are important areas of research.⁵ This section discusses a study in which heat production was measured in vivo during osteotomy preparation at low (maximum 2000 revolutions per minute [rpm]), intermediate (maximum 30,000 rpm), and high (maximum 400,000 rpm) rotational speeds in the rabbit tibia. An inverse relationship was observed between drill speed and heat production with the drills used.⁶

Separate evaluation of the drill configurations used for each available implant system is required to determine, for each type of drill, the rotational speed range and irrigation method that will result in the least heat production. Such data are an indispensable guide for design and use of drills in bone, enabling practitioners to evaluate meaningfully the advantages and disadvantages of the various drill sizes, configurations, materials, and protocols of different implant systems.

Relevant Literature

The conventional belief among members of the dental community is that heat production and resulting bone temperature increase in proportion to drill rotational speed. A review of previous research upon which this belief is founded reveals a lack of data to support this position. To investigate a hypothesis proposed by Thoma,⁷ Thompson⁸ investigated the mechanical effects, thermal changes, and initial histologic responses to the drilling of bone at the various instrument rotational speeds available in 1958. At that time, the highest speed in routine clinical use was 2000 rpm. Accordingly, Thompson⁸ conducted his study within the range of 125 to 2000 rpm. He observed that within this range and without the use of coolant, temperature increased from 38.3° C to 65.5° C as drill speed increased. This finding was confirmed by Pallan,⁹ who drew a linear relationship between drill speed and heat production using a No. 6 round bur. In 1972, Matthews and Hirsch,¹⁰ using a 3.2-mm spiral drill, drew a directly proportional relationship between drilling speed and heat production when comparing speed ranges from 345 to 2900 rpm. In 1980, Lavelle and Wedgewood¹¹ reported increasing heat production with increasing rotational speeds up to 3500 rpm.

In 1984, Eriksson, Albrektsson, and Albrektsson¹² noted in a literature review that “some authors recommend high speed” but concluded that “drill speeds in the range of 1000-2000 rpm are recommended.” However, Eriksson’s and Albrektsson’s report¹³ did not consider in-

vestigations of temperature at water-cooled drilling speeds greater than 2000 rpm. Consequently, the profession came to equate high-speed drilling with high temperature production.

Although numerous researchers have reported histology that is difficult to explain using the paradigm of increasing temperature with increasing drill speed, almost no reports have investigated this conventional wisdom with measurements of local temperatures. In an investigation of drilling speeds in 1962, Rafel¹⁴ reported that the least increase from the resting **baseline** temperature when using No. 703 carbide burs with external coolant and intermittent cutting pressure in a cadaver mandible was observed at speeds up to 350,000 rpm, the highest drill speed used in the study.

Current beliefs are primarily based on two frequently referenced works of Eriksson and Adell¹⁵ and Eriksson and Albrektsson,¹⁶ although neither work scientifically confirmed the assumption that heat production resulting from water-cooled drilling of dental implant osteotomies continues to increase at speeds higher than 2000 rpm. Furthermore, Eriksson et al’s finding that irreversible bone damage occurs at 47° C at 1 minute duration in the rabbit tibia was determined using an electrically heated coil—not by drilling.¹⁷ Clinically, drilling continuously for 1 minute at any stage of osteotomy preparation is contraindicated. Intermittent drilling is the norm.

Relationship Between Drill Speed and Heat Production

To clarify the relationship between drill speed and heat production, an experiment was conducted to measure and compare the temperatures produced by low-speed (maximum 2000 rpm), intermediate-speed (maximum 30,000 rpm), and high-speed (maximum 400,000 rpm) bone drilling using a precisely positioned and calibrated thermocouple in vivo.

The investigations involved New Zealand rabbits, which heal rapidly and have dense cortical bone at the sites used.⁶ Pilot studies also were conducted to test and standardize the procedures. The antero-medial aspect of the tibial metaphysis was used to evaluate heat production, because its bone is thick and dense. Cylindrical osteotomies were prepared in the tibia using 700 XL carbide burs at low (maximum 2000 rpm), intermediate (maximum 30,000 rpm), and high (maximum 400,000 rpm) speeds. Low and intermediate speed ranges were confirmed using a tachometer (Crompton Greaves, UK). The high-speed range was confirmed using an oscilloscope. Ample distilled water at room temperature was used as coolant in conjunction with all drilling.

A total of 18 osteotomies—one at each of the three speed ranges in the tibia of six animals—was prepared. In each instance, a 700 XL carbide bur was used to prepare a site 0.8 mm in diameter and 1 mm in depth for insertion of the thermocouple. The resting bone temperature was measured 5 minutes later (Fig. 5-1). At a distance of 1.0 mm

from the thermocouple site, using a half-round bur for initial entry followed by a 700 XL carbide bur, a cylindrical osteotomy was drilled through the cortex to a depth of 3 mm using intermittent pressure (Fig. 5-2). To protect the probe from direct contact with the coolant and conduction of heat generated by the thermocouple that could alter the temperature profile, the thermocouple was encased up to its terminal 1 mm in a metallic sleeve coated with thermovarnish, and further encased in a silicone sleeve. Temperature was continuously measured throughout the drilling of the osteotomy to ascertain the entire range of temperature production.

The **average** resting temperature was 31.3° C before low-speed, 31.2° C before intermediate-speed, and 31.1° C before high-speed osteotomy preparation. The lowest and highest temperatures observed during drilling were recorded. The resulting high **mean** temperatures were 35.7° C at low speed, 33.5° C at intermediate speed, and 31.4° C at high speed (Fig. 5-3). An **analysis of variance (ANOVA)** indicated statistically significant differences in temperature change among these rotational speed ranges ($p < 0.05$).

The temperature range measured during osteotomy preparation at each experimental drilling speed is shown in Table 5-1. The results of this investigation establish that as the rotational speed of drilling osteotomies increases, the temperature change decreases when using 700 XL carbide burs with appropriate irrigation. At no time did the temperature approach 47° C, the temperature reported to damage bone after 1 minute duration, at any drilling speed range.



FIG. 5-1 ■ Measurement of resting bone temperature 5 minutes after osteotomy preparation.

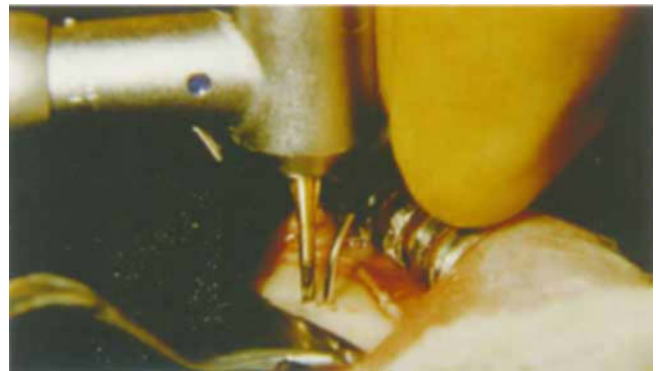


FIG. 5-2 ■ Osteotomy preparation with thermocouple properly positioned.

TABLE 5-1 TEMPERATURE RANGE MEASURED DURING OSTEOTOMY PREPARATION AT LOW, INTERMEDIATE, AND HIGH SPEEDS

Speed	Specimen	Temperature (°C)		
		Low	High	High Value Mean
Low (maximum 2000 rpm)	1	32.1	35.2	35.7
	2	32.1	35.3	
	3	31.9	35.8	
	4	33.2	36.0	
	5	32.7	35.9	
	6	32.0	36.0	
Intermediate (maximum 30,000 rpm)	7	27.2	32.9	33.5
	8	29.8	32.3	
	9	31.0	33.0	
	10	31.1	33.0	
	11	31.9	31.8	
	12	30.0	33.2	
High (maximum 400,000 rpm)	13	27.2	30.6	31.4
	14	27.1	30.5	
	15	28.0	31.0	
	16	27.7	30.9	
	17	28.5	33.1	
	18	30.5	32.2	

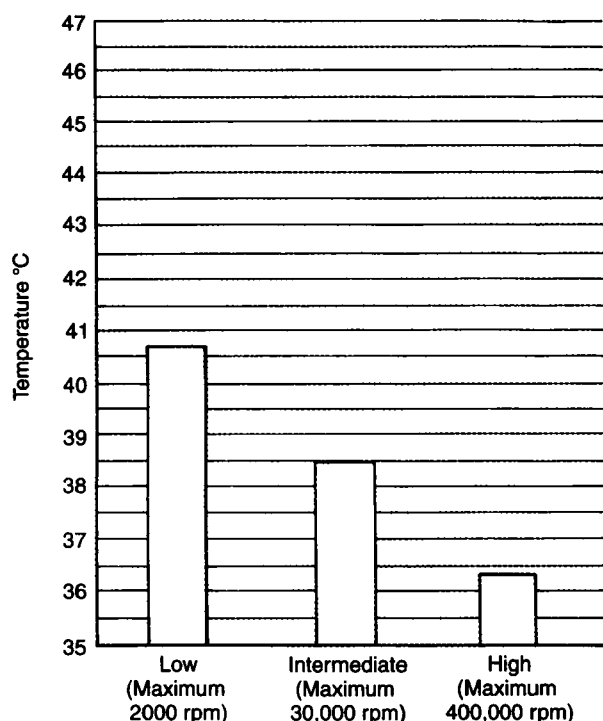


FIG. 5-3 ■ High mean value of temperature at low, intermediate, and high speeds.

This finding may be explained in part by the different mechanics of bone drilling at different drilling speeds. The same researcher used the same type of drill at each of the speed ranges, thereby eliminating variables such as technique, drill configuration (i.e., diameter, blade positioning, and angulation), and coolant delivery system. Thus, the only variable that could account for the difference in heat production was drill rotational speed and associated phenomena. At least three explanations are possible to account for this difference.

First, the amount of time required to drill the osteotomy using the low-speed drill was longer than that required using the high-speed drill. The cumulative effect of the longer duration of heat production in the low-speed osteotomy may have resulted in higher temperature readings at the thermocouple site.

Second, when an edge of a drill cuts through surrounding bone, the new bone surface is heated as a result of friction. Using the higher rotational speed, the next **cutting edge** removes this heated bone more rapidly than when using a low- or intermediate-speed drill, thus allowing less time for conduction of the heat to surrounding bone.

Third, the lower heat production at the high-speed range may be related to the toughness threshold of bone as a function of rate of loading leading to fracture. Toughness is the area under the stress-strain curve (see Fig. 4-15) from initial elastic strain to the point of fracture. Bone has greater toughness but less **ductility** at high rates of strain. In terms of cutting, the toughness depends on rate of load-

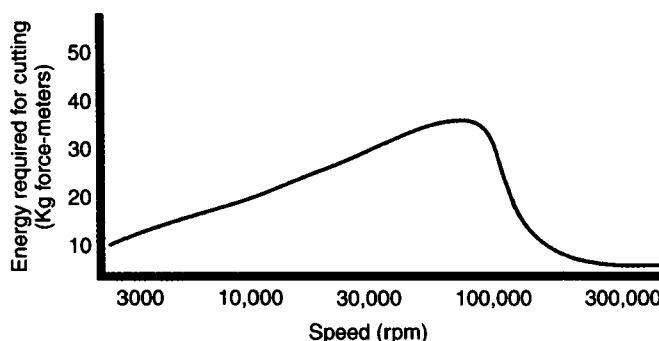


FIG. 5-4 ■ Effect of speed on energy required to maintain cutting effectiveness. Note that above 100,000 rpm a change to brittle fracture mechanism reduces the energy required for cutting.

ing. For drilling in dentin, a **peripheral speed** on the circumference of the drill lower than 300 ft/sec induces a lower loading rate response,¹⁸ whereas a peripheral speed greater than 300 ft/sec induces a high loading rate response. Energy introduced into the system can manifest itself as heat production. More brittle materials fracture, which can require less energy than that required to break up more ductile materials (Fig. 5-4). Thus, the brittle fractures resulting from the higher loading rate may result in lower heat production.

Influence of Bur Design on Heat Production During Osteotomy Preparation

Modifications Related to Rotational Speed. As dental drill rotational speeds increased in the late 1950s, a cycle of modifications of bur sizes and shapes occurred. Smaller-diameter burs replaced larger-diameter burs. The cutting efficiency of carbide burs increased at higher rotational speeds. Small-diameter sizes, with insufficient peripheral speed at lower rates of rotation, became ideal at high speed. Advances included reduced use of **crosscut** burs, extended heads on fissure burs, and rounding of sharp angles.

Fissure and Crosscut Fissure Burs for Drilling.

Crosscuts on fissure burs are most effective at low speeds and tend to produce unduly rough surfaces at high speeds.¹⁹ Highly brittle carbide fissure burs with extended heads require higher applied forces to cut at speeds of 500 to 6000 rpm. This can cause fracture. The minimal applied forces required for cutting at high rates permit modifications that are impractical at low speed.

Design Features. A bur has a neck diameter, head diameter, head length, **taper angle**, **spiral blade angle(s)**, crosscut size, and crosscut spacing (Fig. 5-5). Taper angle and head length vary. A small neck diameter can be weak and unable to resist lateral forces, whereas a large neck diameter may interfere with visibility and restrict access for coolant.

The spiral angle and crosscutting affect performance.²⁰ In low- and intermediate-speed ranges, spiral blades pro-

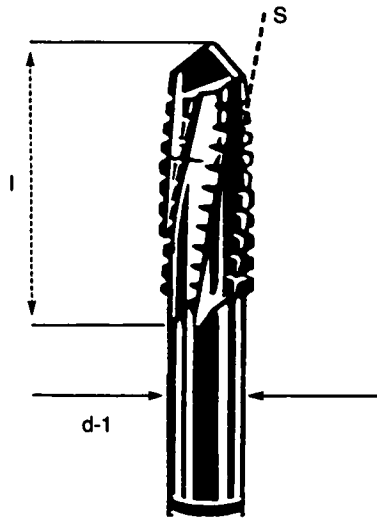


FIG. 5-5 ■ Design features of a cross-cut tapered fissure bur, side view. Head length (l), neck diameter ($d-1$), and spiral angle (S).

mote smoothness. Cutting action is uniform throughout a rotation, because each blade starts cutting before the preceding blade has finished. The spiral angle chip formation and clearance are of particular importance when cutting a narrow groove.

High-speed burs cut smoothly with reduced spiral angles, promoting efficiency. Sufficient perpendicular force is required to make a blade “dig in” and start cutting as it passes across a surface. When attempting to cut a hard surface, or when using a dull blade or bur of greater length, more force is required to initiate cutting. At low speeds, use of at least six blades promotes a smoother cutting action,²¹ which has been shown to promote initial healing.²² At high speed, there is a tendency for the bur to cut with a single blade. It is important that the bur head be symmetrical.

Two features of bur heads are **concentricity** and **runout**. Concentricity, a static measurement not directly related to function, measures how closely a single circle can be passed through the tips of all the blades. Runout measures the accuracy with which all blade tips pass through a single point when the instrument is rotated. It measures concentricity together with the accuracy with which the center of rotation passes through the center of the head. A perfectly concentric head will exhibit substantial runout if it is off-center on the axis of the bur, or the neck is bent, or the bur is not held straight in the handpiece chuck, or the chuck is eccentric relative to the handpiece bearings. Runout can never be lower than concentricity. Runout errors are what cause burs to cut holes measurably larger than the diameter of the bur.

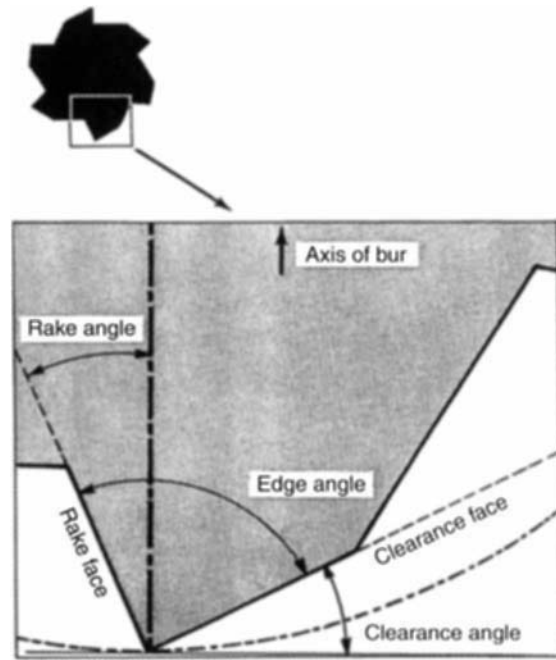


FIG. 5-6 ■ Bur blade design, view from shank end. (From Sturdevant CM, editor: *The art and science of operative dentistry*, ed 3, St Louis, 1995, Mosby.)

Osteotomy Drill Blade Design. Each blade of a bur has two faces: the **rake face**, in the direction of rotation to contact the structure being removed, and the **clearance face**, which follows behind the edge as the bur rotates. The cutting edge of the blade is at the intersection of these two faces. The **rake angle**, **edge angle**, and **clearance angle** are shown in Fig. 5-6. The optimal value of each depends on the mechanical properties of the blade material, the mechanical properties of the material being cut, the rotational speed and diameter of the bur, and the lateral force applied by the practitioner. More positive rake angles are used when relatively soft and weak materials are being cut.

The optimal edge angle is closely related to the resistance of the blade to fracture. The greater the edge angle, the lower the likelihood of fracture of the blade edge. At higher applied forces and greater depth of cut at low speeds, larger edge angles increase service life. Light loads and shallow cuts at high speed permit smaller, more efficient edge angles. The clearance angle eliminates rubbing friction against the exposed bone surface behind the cut edge. A greater clearance angle reduces friction and provides a stop to prevent the blade edge from excessive digging. The clearance angle provides adequate flute or clearance space to keep newly formed chips from the following blade.²³

Cutting Effectiveness and Cutting Efficiency. Cutting effectiveness and cutting efficiency are not the same. *Cutting effectiveness* is the quantitative ability of an instrument to remove bone. Increase in rate of bone removal makes a drill more effective, whether or not undesirable side effects occur. *Cutting efficiency* describes the ratio of the

desired results to the total results. A dull bur, for example, can cut faster than a sharp bur by applying sufficient force. Increasing effectiveness this way significantly increases heat production, thus reducing efficiency. In the low- and intermediate-speed ranges, decreased cutting efficiency caused by dull instruments, or increased speed or force, increases heat production. For any given amount of energy introduced into a system to turn a cutting instrument, inefficiency of the instrument is expressed in the system as released heat.

Energy Production and Heat Transfer. As a bur blade penetrates bone, elastic strain energy is generated by mechanical distortion of bone ahead of the blade. The components of energy absorbed by bone, elastic and plastic deformation, **abrasion** as a function of loading rate, formation of new surfaces, molecular and mineral fractures, and fluid flow phenomena can influence heat produced during bone removal. In the absence of adequate local cooling, temperature can rise in the bone and the bur. However, transfer of heat is not necessarily instantaneous.

Mechanical Properties of Bone. Bone is a composite material composed of hydroxyapatite (HA) crystals combined into a **matrix** phase rich in **collagen**, intercellular **ground substances**, and fluids. The rate of damage to bone during cutting affects its local properties. In general, a faster rate of loading is associated with increased strength and hardness, and lower ductility. At sufficiently high rates of loading, some ductile materials can become brittle.¹⁸

At low rates of loading, bone exhibits more viscoelasticity before it fractures. At higher loading rates, a range is reached at which the bone fractures with less deformation, which could influence heat transfer and changes in temperature.

Role of Abrasion in the Penetration of Bone. Drilling is one of numerous bone removal processes, such as cutting, chipping, cleaving, honing, sawing, grinding, or abrading. Each of these processes has characteristic mechanics. All bone removal processes use various fracturing techniques. Cleavage and impact fracturing are the most conservative of energy and heat but also are the most difficult to control. Grinding and polishing, while versatile, can be energetically expensive and cause incremental heat transfer (Fig. 5-7).

Elastic, Plastic, and Viscoelastic Stress-Strain Patterns. The stress-strain biomechanical behavior of deforming materials can be brittle, ductile, or **viscoelastic** in nature, depending on the material and deforming condition. Brittle materials such as HA crystals allow little plastic deformation. They rupture without demonstrating permanent strain before fracture. Plastic materials such as metals are elastic up to their yield point, followed by plastic flow, which consumes large amounts of work. They may fail by localized rupture with a localized decrease in cross section. Viscoelastic materials such as rubber and polymers can store and dissipate energy with deformation (strain), and fail as a function of the extent and rate of deformation. Abrasion of plastic and viscoelastic

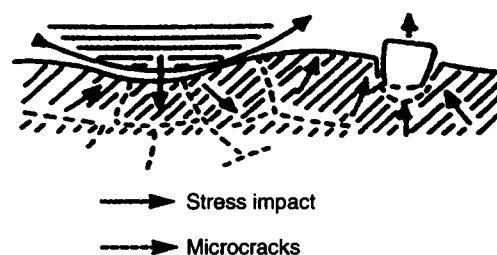


FIG. 5-7 ■ Grinding. Abrasion of a brittle substance causes microcracks, resulting in fatigue-type failure.

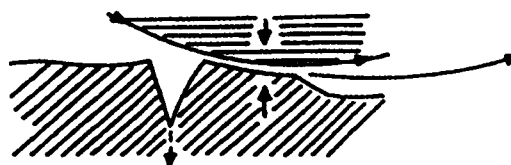


FIG. 5-8 ■ Microcrack causes weakening. Continuing abrasion carries away weakened particles.

materials may cause local changes in molecular structure with increased heating. In a composite material like bone, in which a brittle phase of HA crystals exists as a composite within a viscoelastic matrix of collagen, drilling is more than just a brittle rupture phenomenon. The material characteristics, relative geometries, speeds, forces, and surface modifications of the drill affect efficiency. Careful engineering of the drill to minimize critical surface interactions is imperative.

Drilling proceeds in a rotating fashion involving centrifugal forces. By repeated passing over previously removed surfaces, residual ridges are fractured away (Fig. 5-8). The abrading geometry can be described in terms of plowing, pulling open of cracks, ruptures, and impact processes. The latter aspect can result in vibrations within the surfaces of the abrading and abraded materials that may cause elastic **shock waves**, which in turn may add or subtract from the energy imparted to both surfaces.²⁴

Factors Contributing to Heat Production During Osteotomy Preparation

Drill Diameter. At a given rpm a larger-diameter drill is expected to generate more heat than a smaller-diameter drill, as the rotational contact zone and relative rate along the surfaces are transformed into heat by friction, which is proportional to peripheral velocity. Peripheral velocity is measured as rpm multiplied by drill diameter.¹²

Cutting Characteristics of Drill. The greater the surface area of contact during drilling, the greater the potential for heat production. Burs with longer cutting edges tend to produce more heat than do those with shorter cutting edges. Heat production is inversely proportional to efficiency, as determined by the mechanics of design and

sharpness of the drill. As drilling depth increases, the potential for an increase in heat generation also rises. Heat generation is at its peak for only a short while. Thus, a drill with a large interface area can generate more heat, increasing heat transfer and regional temperature.

Coolants. Irrigating fluids reduce friction and facilitate bone chip removal. Coolant delivered via the central core of the bur reduces heat buildup within the bur, which can influence heat transfer to the bone. As coolant exits from within a bur, the resulting turbulence may lead to bone chip buildup, thereby clogging the flutes, decreasing cutting efficiency, and increasing frictional resistance. The problem of debris plugging irrigation canals in drills has been reported to be common in clinical practice. Because external irrigation has been shown not to affect bone deleteriously, it is at least recommended for adjunctive use.

NATURAL DEFENSE MECHANISMS THAT HELP MAINTAIN ORAL HEALTH

At the pergingival site, the abutment of an implant protrudes through gingival epithelium, and the tissues in this area tend to remain infection-free long-term. Defense mechanisms against infection, both anatomic and biochemical in nature, operate in the oral cavity to help protect tissues from invasion by pathology-producing organisms into the sulcus around the abutment.

Important barriers are **mucopolysaccharides** and the associated hemidesmosomal form of **epithelial attachment**, akin to that around teeth.²⁵ Some mucopolysaccharide-type substances are secreted by crevicular epithelial cells and, as in the case of teeth, are proposed to act as a seal between the epithelium, the implant abutment and neck, and the underlying tissues. Alone, this mucopolysaccharide barrier is weak, but in combination with the hemidesmosomal form of epithelial attachment, a more effective barrier to bacterial invasion is presented.

Another reinforcing defense agent is **phagocytic cells**. Together with other white blood cells, they are found in the connective tissues. Their function is to migrate regionally through single-layer cells to ward off infection. Lymphocyte and macrophage cells of the lymph glands and bloodstream effectively attack bacteria that penetrate nonkeratinized epithelium of the gingival crevice. In addition, these cells secrete specific immune substances against bacteria.²⁶

Another deterrent to foreign bacterial invasion is the normal flora of the oral cavity. These healthy, common bacteria occupy available biologic niches. Other introduced bacteria must be potent and present in large numbers to successfully compete for a niche in a healthy oral cavity.

To further bolster these defense mechanisms, **enzymes** are secreted by the mucosa and salivary glands, many of which are bactericidal. Lactoperoxidase and lactozyme, for example, are effective against staphylococcus, streptococcus, and several other harmful bacteria. In addition, secreted **immunoglobulin A (IgA)** is responsible for pro-

tecting most body openings against disease and does so effectively in the implant sulcus.

NATURE AND DISTRIBUTION OF HEALED INTEGRATING TISSUES AROUND ENDOSTEAL DENTAL IMPLANTS

Integrating Tissues

Cortical and cancellous bone, marrow, collagenous tissue, and neurovascular structures are macrostructures observed at the interface of endosteal dental implants at the light microscopic level. These same tissues are observed around tooth roots within bone. In the cases of the **osteo-preservation** and **osteointegration** modes of tissue integration, the percentages, arrangement, and distribution of these integrating tissues differ.²⁷

A physiologic function of the alveolar ridge is to invest the roots of natural teeth and to transmit the stress of occlusal forces as they pass through the tooth root for **absorption** within the force-dissipating periodontal ligament and surrounding bone. Histologic observation of healed edentulous alveolar ridges at the light microscopic level reveals a sparsity of trabeculation caused by hypofunction of the ridge following tooth removal. The original trabeculation of cancellous bone associated with the once-present tooth roots is no longer observed. Over time, reorientation of the remaining cancellous bone also takes place, and the periodontal membrane is no longer present.

Following the insertion and healing of an endosteal dental implant, the investing tissues within the alveolar ridge resume their role to transmit and absorb the forces of occlusal function. In response to the direction, magnitude, duration, and character of functional forces, new bone and collagenous connective tissue is laid down to become part of the healed tissue integration around the implant. A significant amount of new bone that was not present at the time of implant insertion can form during postsurgical healing. This bone remains and remodels long-term in association with the functioning implant. This is why selection of implant type and osteotomy location based on presurgical trabecular density is questioned by some practitioners, as opposed to predicting the nature of the bony support that will be present after healing, functional remodeling, and reorientation of tissue.

Control of Mode of Tissue Integration

A portion of an implant in proximity to cortical or cancellous bone at insertion will remain closely associated with cortical or cancellous bone after healing. The existence, amount, and distribution of collagenous connective tissue is determined by the biomechanical stress pattern at the interface during healing and subsequent function. One-stage hypofunctional healing with controlled micromovement is believed to promote the controlled deposition of a collagenous, osteogenic peri-implant ligament and the osteopreservation mode of tissue integration.^{28,29} Two-stage **afunctional** healing, in the absence of micromovement,

promotes the osteointegration mode of tissue integration. Thus, by carefully following the treatment protocols for each implant modality, the practitioner controls the nature of tissue integration.

Percentages of Integrating Tissues in Direct Apposition at the Interface

The percentage of total interface area of cortical and cancellous bone is distinct from the percentage of the real contact area of each at the implant interface. This distinction has important physiologic and biomechanical implications. The area at the interface, less areas of marrow spaces, lacunae, and collagen fibers, yields the area of real contact. In the case of cancellous bone, one must be particularly sure to subtract the area of the marrow spaces.³⁰ Interface areas associated with cancellous bone normally have a lower percentage of direct contact than those associated with cortical bone.

In the case of functioning osteopreserved plate/blade forms, one must consider the nature and distribution of the implant cribriform plate (socket), the bone most closely associated with the implant interface into whose trabeculae the osteostimulatory collagen fibers of the peri-implant ligament insert.

It has been shown that in the case of osteointegrated endosteal implants, the percentage of total area of each tissue associated with the implant interface varies with implant location.³¹ In the mandible, because of the presence of dense and thick cortical plates, 25% of the total interface area of root forms and 45% of the total interface area of osteointegrated plate/blade forms are associated with the internal aspect of cortical bone.³² Thus, 75% of the total interface area of root forms and 55% of the total interface area of plate/blade forms are associated with cancellous bone. In the case of implants with the diffusion-bonded microsphere interface, the bony ingrowth into its porosities has trabecular characteristics, regardless of whether cortical or cancellous bone is closest to the interface. In the maxilla, where the cortical bone is thinner and less dense, a significantly smaller percentage of the total interface area of any endosteal implant is associated with cortical bone. This may in part explain reduced maxillary success/survival rates and the advantage of positioning the implant against cortical bone in the maxilla.

The total area of cortical plus cancellous direct bone contact at the afunctionally (submerged or semi-submerged) healed, unloaded interface of osteointegrated endosteal implants in humans, primates, and dogs ranges from 35% to 62%.³⁰ Osteointegrated plate/blade forms generally show higher levels of direct bone contact.³² These percentages of direct bone contact are sufficient for clinically functional osteointegration. The percentage of direct contact is higher in areas of cortical than of cancellous bone. The remaining 38% to 65% of the interface area not in direct contact with bone at the interface is in contact with marrow and collagenous connective tissue fibers.

Histology of clinical specimens suggests that the total area of cortical plus cancellous direct bone contact at the

hypofunctionally (nonsubmerged) healed, unloaded interface of osteopreserved plate/blade form implants in humans, primates, and dogs is low. Thus, the osteostimulatory peri-implant ligament is the primary tissue responsible for bearing load around healed plate/blade forms in the osteopreservation mode of tissue integration.

The tissue types involved in the integration of natural teeth, osteopreserved, and osteointegrated dental implants are the same. What differs are the percentages, distribution, and orientation of each tissue type at the interface. These percentage differences result in the markedly different biomechanical aspects of function of osteopreserved and osteointegrated implants. This in turn dictates the **case sequencing** that must be followed to achieve the chosen mode of tissue integration and the necessity or contraindication of using natural tooth co-abutments under the prosthesis, and also influences the nature of required occlusal restorative materials.

RELATIONSHIP BETWEEN HEALING AND CASE SEQUENCING

Submerged or semi-submerged afunctional healing is mandated for endosteal implants intended for osteointegration. Healing time ranges from 3 to 9 months depending on the arch, the volume and character of bone into which the implant is placed, and the overall host environment.

The reason the healing protocol is this long is because afunctional healing deprives the site of stimulation that would normally promote the rate of healing. Consider how rare it is for traumatic bone fractures, in which bone heals through callus formation, to take up to 9 months to heal. The bone usually is put into a state of hypofunction very shortly after injury. Afunctional bone healing requires not only relative immobilization but also stimulation.^{33,34} In the case of dental implants, stimulation means that during the healing period, forces of low magnitude and duration are applied through the immobilized implant into the surrounding tissues. Afunctional (submerged) healing carefully avoids such stimulation, which in turn affects the rate of healing. Thus, case sequencing and total elapsed time of treatment are inseparably related to the mode of tissue integration selected for the case at hand.

TISSUE HEALING

Healing by Primary Intention

Epithelial Migration/Contact Inhibition. Study of the repair and regeneration mechanisms of tissues includes investigation of the properties of epithelial tissue. Although repair of the underlying connective and osseous tissues is occurring, epithelial cells migrate to cover and seal the wound.²⁶ The phenomenon of **epithelial migration** is well documented. Because of **contact inhibition**, these cells do not migrate down and along the implant interface to envelop the implant.^{35,36} In general, epithelial cells have been shown to proliferate and migrate across the wound only until they touch other normal collagenous connective tis-

sue or epithelial cells migrating from the other side, which act as an effective contact inhibitor to halt migration. This is why the implant is not encapsulated by epithelium. When the cells migrate down, they meet normal collagenous fibers, which again inhibit migration.²⁵

Healing by **primary intention** is promoted when careful cleansing and trimming of the edges of the incised border of each flap is followed by secure coaptation with a sufficient number of gently and appropriately placed sutures. This ensures that tissue will not granulate into voids, required epithelial migration distances are minimal, and healing is thus not only more rapid but also more resistant to early tissue separation under tension.

If the underlying connective tissue collagen fibers become inflamed or infected, epithelial cells may invade and bone loss may follow. If this occurs, as in the case of natural teeth, pocket formation results.³⁰ The treatment is the same for both natural teeth and implants. Contact inhibition thus also becomes an important oral defense mechanism to protect the viability of the gingival sulcus around implant pergingival sites.

Pergingival Site

Preservation of Attached Gingiva. Attached gingiva at the crest of the healed partially or totally edentulous alveolar ridge is a precious commodity. It is a narrow band bucco/labio-lingually, running the mesio-distal length of the ridge crest. Properly located incisions should bisect this band of attached gingiva, and following **tissue reflection**, every effort is made to place and suture the attached gingiva such that it will be present at the entire circumference of what will become the pergingival site of the abutment. This leads to enhanced prognosis because of enhanced cleansability and the presence of a gingival sulcus that can be maintained long-term.³⁷⁻³⁹ Ensuring the presence of attached gingiva at the pergingival site offers the option, for all implant modalities, of **ridge lapping** the crowns overlying the implant abutment to predictably provide acceptable esthetics and gingival health⁴⁰ (see Controversy box).

Ensuring the presence of attached gingiva is easy for one-stage implants, in which the abutment projects through the gingiva at the time of insertion, and semi-submerged implants, in which a healing collar is flush with or up to 1 mm above the gingival crest at the time of insertion. In such cases, it is a simple matter to suture attached gingiva tightly in place around the implant pergingival site. When an implant is case sequenced to follow the submerged healing protocol, attached gingiva is sutured over it. In such cases, the relationship of the attached gingiva to the abutment that will protrude pergingivally may not permit the presence of attached gingiva at the margins.

It is advantageous to preserve the attached gingiva and ensure its presence around the pergingival site of each healed implant.⁴¹ For these reasons, the trend today is toward semi-submerged rather than submerged healing of osseointegrated implants. During healing, this requires more careful hygiene and attention to providing adequate

CONTROVERSY

Ridge Lapping of Implant Abutments

Crowns placed on natural teeth cannot be successfully ridge lapped, although this technique is common for pontics. For this reason, the concept that ridge lapping implant abutments may be beneficial is counterintuitive. Nonetheless, ridge lapping of root form, plate/blade form, and subperiosteal implant abutments has been performed successfully for several decades by many practitioners, with very favorable results long-term. This may be because these abutments exhibit a pergingival site in attached gingiva. Thus, ridge lapping a root form that has been treated with the semi-submerged protocol is possible, whereas when a root form is treated with the submerged healing protocol, it is far more difficult to ensure the presence of attached gingiva completely surrounding the abutment at the time of attachment, and therefore ridge lapping may be contraindicated.

relief of the tissue surface of the overlying provisional removable prosthesis when one is used.

Gingival Sulcus. Dental implants are unique in that in function they protrude through a pergingival site into the oral cavity. The nature of this site, its histology, and the biochemistry, physiology, and oral defense mechanisms that together act to ensure long-term health are well described and understood.^{25,26,37} The implant sulcus can remain in health indefinitely. In the 1960s and early 1970s, for all implant modalities, it was thought that the prime area of pathology would be associated with the pergingival site and the gingival sulcus.⁴² Today, we know that these areas are not troublesome, and that histologically they resemble the structures observed around natural teeth and enjoy the benefits of the same oral defense mechanisms against inflammation and infection. Somewhat unexpectedly, no correlation has been found between **gingival index** scores and degree of bone resorption.⁴³

When pathology is observed in this area, its etiology is analogous to similar problems associated with natural teeth. In one study, gingival health around implant abutments was found to be generally superior to that around natural tooth co-abutments supporting the same bridge.⁴⁴ It was proposed that since implants have no cementum, this may preclude the presence of certain toxins associated with cementum that may be factors in periodontal disease.

OSSEOUS HEALING

Response to Surgical Intervention

Bone is unique among tissues in that it can alter its configuration and even its properties according to variations in functional load. It is self-repairing, anisotropic, multiphased, nonhomogenous, and exhibits complex geometric structures. Its mechanical stress and strain characteristics are viscoelastic in nature. All these factors make the study of bone properties complex.

To understand how an implant can function within physiologic limits of health, one should consider information from many areas including physiology, biochemistry, biomaterials, and biomechanics in relation to normal repair and regeneration mechanisms. Providing that the implant material is biocompatible and that correct insertion techniques are employed, healing after the insertion of an implant can be described using known repair mechanisms.

When an endosteal implant is inserted, epithelium, connective tissue, and periosteum are incised, and bone is removed in creating the osteotomy to receive the implant. This causes tissue injury and induces an expected slight inflammatory reaction. A cellular response is induced in which **pluripotent cells** undergo **cell differentiation** into the variety of cell types required for healing.⁴⁵ Biochemical and **bioelectric signals** have been described to occur to influence the processes of **angiogenesis** and **osteogenesis**.⁴⁶⁻⁴⁸ Although these responses occur naturally in response to tissue injury, factors within the clinical protocol directly affect them and therefore influence the results. These factors will be discussed now in greater detail because of their direct relationship to clinical treatment protocols.

During bone healing, the pH changes at the site of the injury. Bleeding, local changes in pressure, and **edema** follow injury. Some cells burst, spilling toxins into the surrounding area,⁴⁹ and certain bioelectric and biochemical phenomena are known to occur. In response to these and other factors, pluripotent cells, marrow cells, and cells lining the periosteum and **endothelium** act as sources of fibroblasts, **osteoblasts**, and **osteoclasts**. Within 48 hours, a clot is organized, and the fibroblasts begin to lay down threadlike collagen fibers. Meanwhile, bloodborne cells continue to lyse and remove debris. With circulation partially interrupted, bone cells at the osteotomy can lose vitality. This dead skeletal tissue can act as scaffolding, and collagen fibers fill in around the implant and walls of the osteotomy. The dead bone is slowly replaced, and the regions including the collagen fibers gradually ossify. Thus, as old bone is removed, new bone regenerates in its place around the implant.⁴⁴

Healing Progression and Timing— Microcorrosion Casts

The first tissue to contact the implant interface includes blood. It has been proposed that the histologic structure's earliest biologic response initiates the tissue integration process. It is through the **microvasculature** that the **nutrients** serving the osteogenic metabolic response travel. This process can be understood through examination of what is known about the earliest progressive changes that occur at the site. Central to this is the knowledge that some aspects of the cellular response follow the progression of microvasculature.

Histologic and physiologic evidence of this sequence has been provided using an injection method for the preparation of **microcorrosion casts**, to make it possible "to observe both bone formation features at the implant

BOX 5-1 ■ STAGES OF HEALING OF TOOTH EXTRACTION SOCKETS

Granulation stage
Initial angiogenic/neurovascular stage
New bone formation stage
Bone growth stage
Bone reorganization stage

interface, and the three-dimensional microvasculature architecture . . . providing an observer at the center of an implant socket a view of a panoramic scene of the angiogenesis and osteogenesis at the tissue walls approximating the implant interface."⁵⁰ A study using similar methods to investigate healing in the postextraction tooth socket⁵¹ serves as a comparative basis.

A formulation of methyl methacrylate was injected at 20° C and allowed to polymerize in the bodies of *Macaca mulatta* monkeys for 2 hours at room temperature. Specimens were gathered, frozen, and sectioned to produce longitudinal and cross sections through each implant. The sections were treated with 2% sodium hypochlorite (NaClO) to accomplish total soft-tissue digestion. All that remained were the inorganic portions of bone and the polymerized methyl methacrylate that penetrated throughout the entire vascular system and into its youngest and finest **sproutings**. The vessel walls were digested. Casts were now prepared for sputter coating with gold for examination by scanning electron microscopy at accelerating voltages of 5 to 25kV, using a JSM-T300 (JEOL). Fig. 5-9, A shows a microcorrosion cast of the vasculature of the periodontal membrane and the surrounding socket of a central incisor that was extracted after animal sacrifice.⁵¹⁻⁵³

Healing Tooth Extraction Sockets. The stages of healing of tooth extraction sockets are shown in Box 5-1.

The progression of osseous healing after tooth extraction is nearly equivalent to that observed for usual wound healing. The microvascular characteristics and pattern of bone formation before the remodeling phase are similar but not identical.

Granulation Stage. The granulation stage extends for approximately 5 days from the time of extraction. Early granulation tissue is observed at the base of the socket, extending crestally along the socket wall. A blood clot occupies the central portion of the socket. The earliest angiogenesis observed is sprouting or budding extensions of preexisting blood vessels—**sinusoidal capillaries** developing from broken ends of blood vessels in the remains of the periodontal ligament at the cribriform plate (Fig. 5-9, B). This angiogenesis starts at the base of the socket, where thick, strong trabeculae already exist and are arranged longitudinally, along with their accompanying capillary plexus. Thus, the area at the socket base, which is injured the least during tooth removal and maintains its vascular pattern intact, is the most active area initially.

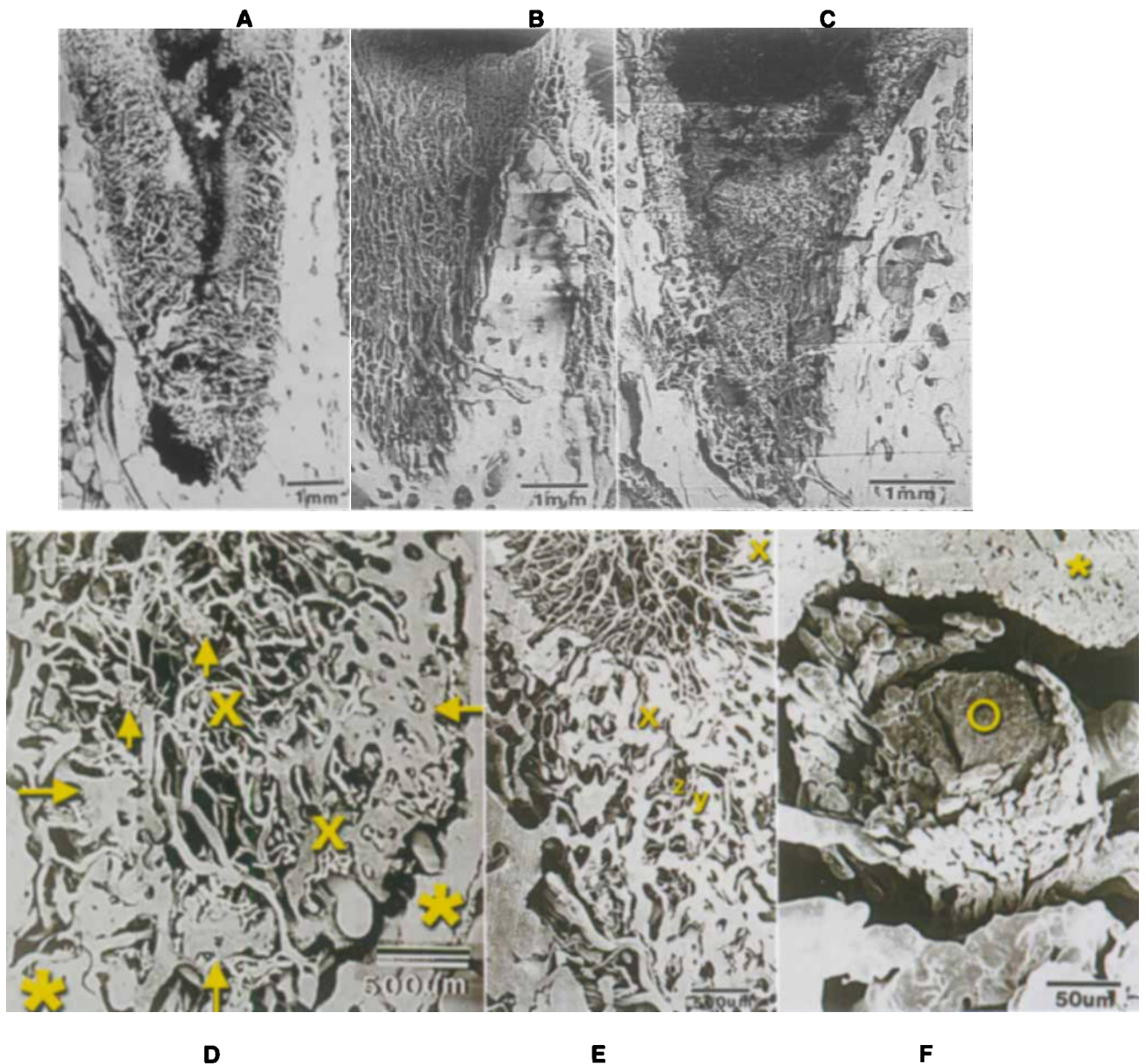


FIG. 5-9 ■ A, Microcorrosion cast of the vasculature of a periodontal ligament of the central incisor of a *Macaca mulatta* monkey. B, Microcorrosion cast 5 days after extraction. C, Microcorrosion cast 1 week after extraction. Arrow, Blood clot; *, Immature sinusoids. D, Microcorrosion cast 2 weeks after extraction. Arrows, Newly formed bone trabeculae; *, Preexisting alveolar wall; X, Mature sinusoids. E, Microcorrosion cast 5 weeks after extraction. X, Primary spongiosa; y, Secondary spongiosa. F, Microcorrosion cast 5 weeks after extraction. O, Preexisting blood vessel; *, Newly formed bone. (A to F, Courtesy J. Shimada, Japan.) *Continued*

Initial Angiogenic/Neurovascularization Stage. The initial angiogenic/neurovascularization stage period extends for 1 week from the time of extraction. The blood clot becomes smaller. The new **sinusoids** extending along the socket wall from the base move beyond the height of the clot, until about two thirds of the socket is filled with newly formed sinusoids. At the base of the socket, the first new bone trabeculae may be observed (Fig. 5-9, C).

New Bone Formation Stage. The new bone formation period occurs approximately 2 weeks from the time

of extraction. Now the entire socket is filled with granulation tissue replete with newly formed sinusoids. The bony wall of the base and sides of the socket presents a dense lattice of trabeculae (Fig. 5-9, D). There is an intimate interrelationship between immature sinusoids exhibiting **anastomosis** and new bone. No new bone trabeculae are observed in areas of nonanastomosing sinusoids or blind ends of sinusoids.

Woven bone is delineated by incompletely ossified trabeculae. Bone trabeculae formation is governed by the ex-

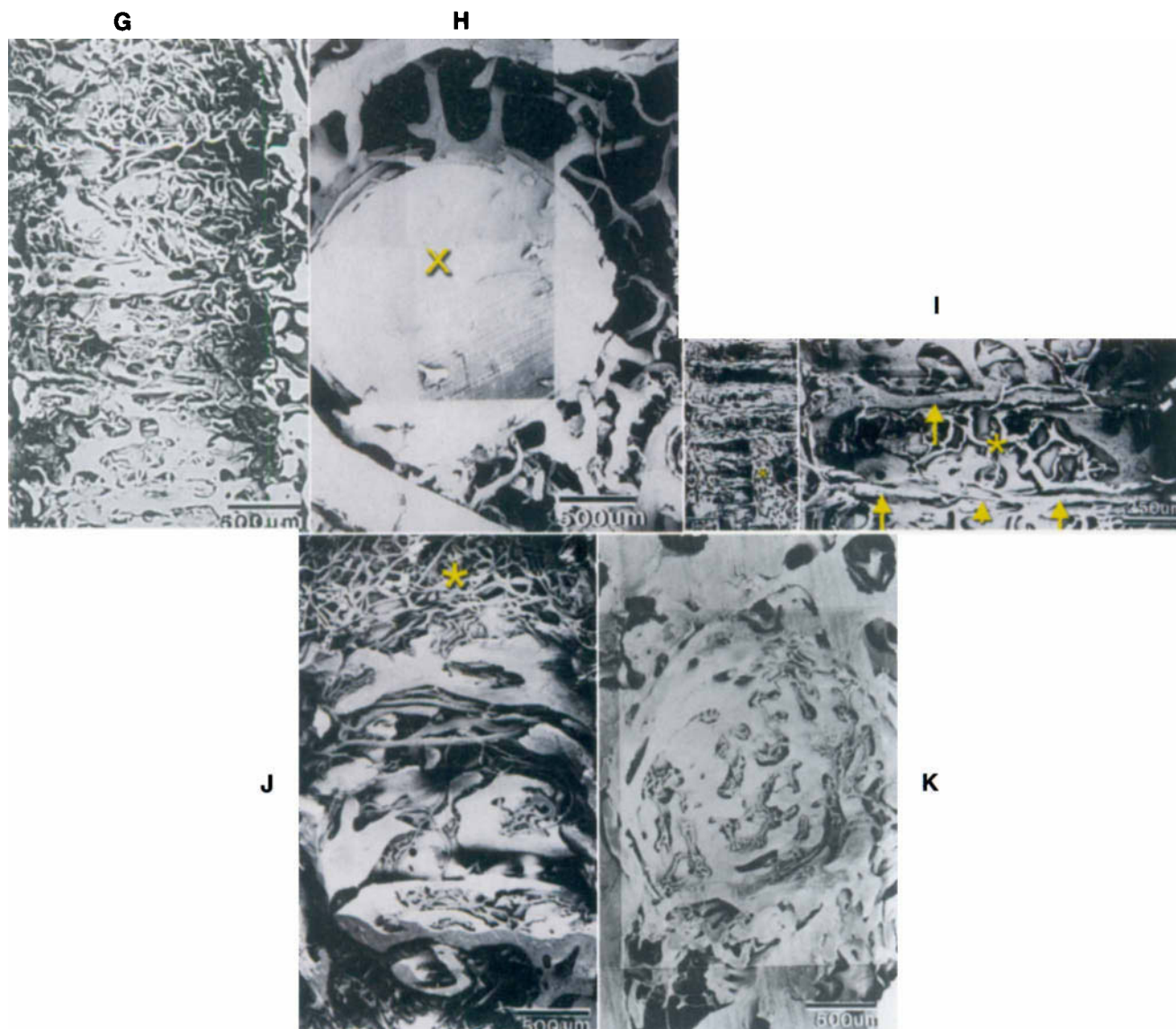


FIG. 5-9, cont'd ■ G, Microcorrosion cast 2 weeks postinsertion of a two-stage titanium cylinder. H, Microcorrosion cast 4 weeks postinsertion of a one-stage titanium cylinder. X, Cross-section of implant. I, Slight (*left*) and greater (*right*) magnifications of microcorrosion cast 4 weeks postinsertion of a two-stage titanium cylinder. Note intimate relationship of blood supply to new bone. Arrows, Ridgelike bone trabeculae; *, Islandlike trabeculae forming in capillary network. J, Microcorrosion cast 9 weeks postinsertion of a two-stage titanium cylinder implant. *, Capillary network. K, Microcorrosion cast 20 weeks postinsertion of a two-stage titanium cylinder implant. (G to K, Courtesy Yoshikuni Ohta, Japan.)

pansion and locations of sinusoids. This activity reaches its peak in the second week following tooth extraction. Bone development becomes rapid.

Bone Growth Stage. The bone growth stage occurs 4 to 5 weeks following tooth extraction. Additional trabeculae are deposited, and the base and walls of the socket have thickened and now occupy about two thirds of the original socket volume. The secondary spongiosa of the next stage begins to develop (Fig. 5-9, E). In areas where sinusoids are still evident, new bone forms. In mature spaces, sinusoids are not observed (Fig. 5-9, F).

Bone Reorganization Stage. The bone reorganization period occurs approximately 6 weeks after tooth extraction. Primary spongiosa reorganize into an irregular and larger framework as secondary spongiosa, again starting at or near the base of the socket, extend upward rapidly.

Healing Around Endosteal Dental Implants. The stages of healing around endosteal dental implants are shown in Box 5-2.

When microcorrosion casts are used to observe the healing progression around endosteal dental implants, the osseous and fibrous elements that differentiate from

the pluripotential cells that arise from mesenchymal tissues must be analyzed. As with natural tooth socket healing, these cells cannot participate in healing and repair without angiogenesis, the development of the nutrition-supplying vascular sprouting complex. This is true whether an implant heals afunctionally or hypofunctionally. Osseous healing around dental implants is suggested to occur in four stages, although differences in the interpretation of stages and nomenclature have been reported.^{54,55}

Stage One: Vascular Sprouting Stage. The vascular sprouting period occurs 3 to 7 days following implantation. It is the earliest angiogenic and osteogenic phase, corresponding to the beginning of the vascularization stage following tooth extraction. This early evidence of angiogenesis is found where elongation of broken ends of fine blood vessels occurs, located in the walls of the prepared osteotomy. Additionally, this is observed in the vascular sprouting observed from immature sinusoidal capillaries invading the granulation tissue. Both of these expand into the peri-implant space from the walls of the bone marrow cavities lining the osteotomy.

Pluripotential cells are activated, but not over the entire surface of the implant. More activity is observed in threaded grooves or acute angles of interface geometry. After the first week, these are rapidly filled with fine collagen fibers and fibroblasts, and in some cases with undifferentiated mesenchyme. Newly formed sinusoidal capillaries infiltrate 10% to 20% of the area. Both the initial and rapid tissue responses and microvascularization start in the grooves and threads of the interface architecture, not on the average level surfaces of an interface, in the cases of both one- or two-stage implants. Thus, this finding has little or nothing to do with micromovement.

In the case of plate/blade form implants, new bone trabeculae isolated from one another are observed early in the blood clot period. This corresponds to the crestal portion of the implant osteotomy, which is expected to show **ossification** earlier because it was originally narrow. Root form threads and grooves, and the **shoulder** of plate/blade forms, are known to facilitate early fixation of the implant.

Stage Two: Early Bone Formation Stage. The early bone formation period occurs 2 weeks after implantation. It is the initial osteogenic stage and corresponds to the formation of bone trabeculae in the tooth extraction socket. Again, vascular ingrowth precedes rapid osteogenesis.

Ridgelike bone with sinusoidal capillaries filling grooves is observed (Fig. 5-9, G). Discontinuous bone segments at the base adhere with a basketlike capillary network and develop into continuous new bone. The initial osteogenic unit is composed of one sinusoidal capillary and its first new bone segment. In some cases, a thin fibrous connective tissue appears between the interface and new bone, even as late as 2 weeks following implantation.

Stage Three: Bone Growth Stage. The bone growth period occurs 4 weeks following implantation. The initial primary spongiosa transforms to secondary spon-

BOX 5-2 ■ STAGES OF HEALING AROUND ENDOSTEAL DENTAL IMPLANTS

Vascular sprouting stage
Early bone formation stage
Bone growth stage
Bone maturation stage

giosa and proliferates to form new alveolar bone. Four weeks after implantation, bone trabeculae originating from the osteotomy over the peri-implant space perpendicular to the interface form a bone plate on and tangential to the interface, referred to as *stalked-bone trabeculae* (SBT) (Fig. 5-9, H). When a scanned section is viewed from the center of the implant socket, islandlike bone plates and their capillary network occupy the peri-implant space twining around the SBT (Fig. 5-9, I). Kaneda⁵⁶ has suggested that excessive interference fit at the time of implantation may hamper tissue reaction and pluripotential cell differentiation.

In some cases, partial bone formation on the titanium interface is interspersed between rich capillary networks that are thought to be precursors of a fibrous layer. What signals this occurrence, possibly micromovement, is not conclusively known. It ultimately matures into the osteopreservation mode of tissue integration.

Stage Four: Bone Maturation Stage. The bone maturation period extends from 6 to 8 weeks following implantation. At this time, the formation of bone around the implant nears completion. A capillary plexus is now evident between the original bone bordering the osteotomy and the new bone bordering the implant interface (Fig. 5-9, J). The new and old bone interconnect, with their vascularization originating in bone marrow. The implant socket or wall starts to reveal small areas of new bone compaction. Bone within threading and grooves begins to fill in. At the implant socket base, several strong, thick plates of trabecular bone appear, resembling the cribriform plate of alveolar bone. At the interface base, vascular elements pass through perforating channels (Fig. 5-9, K).

At porous interfaces, it has been reported that pores larger than 100 nm in diameter can accommodate bone ingrowth. Additional healing time is required in such cases.

In the case of the plate/blade form implant, vascularization and bone formation at the interface occurred in approximately 1 week less time than was observed for root form implants.

Conclusions. Although variations in configuration and materials make a difference, a general pattern of vascularization followed by and then concurrent with bone formation is observed. The sinusoidal capillaries provide the initial evidence of angiogenesis. They mature into capillaries, always located outside the newly formed bone wall.

Healing Response to Controlled Injury

Prerequisites for Optimal Bone Healing Response.

The healing progression and timing as observed in scanning electron microscopy studies of microcorrosion casts has as its underlying basis certain bioelectric, biochemical, and **cell-generated signal** occurrences. The vascularization and bone formation that follow implant insertion require the presence of adequate relevant cells to promote healing, a dependable source of nutritional elements for these cells, and the required signal stimuli to initiate and promote the process. The influence of pH and oxygen saturation are also known to be germane.

Of prime importance is the injury that initiates the response, which sensitizes cells to influence growth factors and stimulates new soft-tissue and bone formation. The very delicate tissue balance among the elements required to promote tissue repair can be affected by external influences such as the absence or presence of micromovement, postulated to promote the presence of osseous and/or osteostimulatory peri-implant ligament tissues. This is in response to most levels of injury, which in a sense initiates the repair process. Excessive injury, on the other hand, may hinder progress, slowing or actually halting the repair process.

Although research in these areas is vast, the vagaries of stimulation of bone repair have not yielded very many significant breakthroughs to enhance current clinical practice, although broad applications will continue to develop and evolve. **Bone morphogenic protein (BMP)** has been shown to induce bone growth,⁵⁷ and its clinical application is being developed to provide safe, effective, and predictable results. Another promising clinical application is to use pluripotent cells that are harvested from a patient, grown in vitro, and then placed at the site of bone injury. The cells develop into bone cells.⁵⁸ Platelet-rich plasma (PRP) harvested from the patient is being evaluated for its potential to substantially reduce healing time.

Tissue Structure and Cell Population. Mature or lamellar bone, as a result of the orderly apposition of morphologically uniform lamella during growth and remodeling, is distinguished by its characteristic anatomy.⁵⁹ Lamella range from 4 to 12 μm in thickness, and enclose osteocytes. Osteoblasts, which form them, are fewer in number and occupy flatter lacunae lining the lamellar surfaces.

Immature bone has been shown to exhibit greater numbers of osteocytes, depending on origin and location, with two variations most often called *woven* and *bundled bone*. Woven bone exhibits a variety of orientations of its collagen fibers, and bundled bone exhibits thick collagen fibers running parallel to one another, with osteocytes positioned among the structural components.

Histologically at various times after implant insertion but before full maturation, one observes a mix of mature and immature bone at various stages of formation, modeling, and remodeling.

Pluripotent cells, variously named and morphologically slightly different from one another according to stage

of healing and area of observation, proliferate and can give rise to the cell population associated with healing and repair. These cells are found in the deepest layer of the periosteum that covers the outer surface of bone, in the endosteum that covers the internal surfaces of the bony walls of all cavities in cancellous bone, in marrow cavities, and in Haversian canals in compact bone.

The periosteum is a multilayered, thick, vascular connective tissue zone. Its thin inner layer, termed the *osteogenic layer*, contains pluripotent cells. Its thicker outer layer is composed of irregularly arranged dense collagenous fibers and is termed the *fibrous layer*.⁶⁰

The endosteum can be thin and comprises a series of flat osteogenic cells embedded within a fibrous matrix. The endosteum functions in bone stasis and turnover throughout life. The osteogenic cells of the periosteum and the endosteum both contribute to healing and repair.

Sharpey's fibers, perforating fibers at the end of bundles of collagenous tissues, extend across the outer regions of the periosteum and through its inner region to anchor into the interstitial systems and regional structures of mineralized bone. They appear as irregular dark lines in decalcified and stained bone, often passing perpendicular to and into the bone structure orientation. These fibers attach the periosteum and the bone, and are more concentrated at sites where tension forces are exerted on bone, such as muscle-tendon insertions. A related situation exists for subperiosteal implant envelopment, as described in Chapter 6.

Bone marrow tissue is **hematopoietic** and contains osteogenic elements. Red cell marrow is present in large cavities in childhood membranous bone and is replaced by yellow fatty marrow in teenage years, except in cancellous bone of the skull, clavicle, vertebrae, sternum, pelvis, and long bones. Bone marrow has a framework of reticular tissue ground substance that holds sinusoids, blood vessels, and hematopoietic cells.

Blood, lymph vessels, and nerves exhibit a basic and simple tissue morphology in all but the long bones. The periosteum supplies marrow, cancellous bone, and compact bone with many of its arterioles. In the Haversian systems, capillaries are drained by a vascular plexus formed by an entwining of vessels that pass into the periosteum and surrounding musculature. The plexus is drained by the systemic veins of the musculature. Lymphatic vessels, most prominent in the periosteum, are also observed in Haversian canals, Volkmann's canals, and marrow. Many nonmyelinated and myelinated nerves are also observed in the periosteum. They accompany blood vessels into the bony interior along parallel pathways.

Factors That Stimulate Bone Repair. Factors that stimulate bone repair are shown in Box 5-3.

Biomechanical Stress-Generated Bioelectric Signals. Healthy, strong bone is maintained when it is biomechanically stressed within physiologic limits. The cancellous bone around an osteopreserved implant can be densely packed, forming a cribriform plate similar to the socket or dental alveolus around a natural tooth. In the case of the osteopreservation mode of tissue integration, the trabecu-

BOX 5-3 ■ FACTORS THAT STIMULATE BONE REPAIR

Biomechanical stress-generated bioelectric signals
 Cell-generated biochemical signals
 Ground substance-generated biochemical signals

lae of the cribriform plate can serve as origins and points of insertion of the collagenous fibers that invest the implant. These fibers are functionally equivalent and morphologically similar to the periodontal ligament fibers that invest the roots of natural teeth. In the case of some dental implants, the collagen fibers originate at a trabecula of cancellous bone on one side, weave their way around a portion of the implant, and reinsert at another trabecula, preferably not too far away.^{28,39} These collagen fibers have been shown to functionally tie and anchor the implant in place. Forces of occlusion load the collagen fibers, which can deform the trabeculae into which they insert, producing an osteostimulatory effect to promote and maintain bone growth. In general, the shorter the collagen fiber, the greater the force transmitted, and the greater the resulting osteostimulatory effect. Plate/blade form configurations designed to control collagenous fiber length have properly dimensioned struts, and Innova Endopore root forms have porosities formed by diffusion-bonded microspheres, around which short collagen fibers may wrap to achieve this osteostimulatory effect.

Root form implants are larger in diameter. If a root form implant does not osteointegrate as intended, it is postulated that the collagen fibers that wrap around the bulk of the implant before inserting at a trabecula of bone are excessively long to have an osteostimulatory effect, because their length may internally dissipate too much functional stress. In time, such implants tend to exhibit thickened ligaments and resulting **mobility**, and may exfoliate.²⁸

The osteostimulatory effect is responsible for the continued growth and remodeling of the adjacent cancellous bone and cribriform plates within which natural teeth and osteopreserved implants function. Orthodontists, by carefully controlling the compressive and tensile forces placed on trabeculae by periodontal ligament fibers during tooth movement, cause bone to resorb in front of and form behind the direction of tooth movement as they alter tooth position in the alveolar ridge. This formation of bone in the wake of the tooth is caused by osteostimulation. Another occurrence that clinically demonstrates the osteostimulatory effect of collagen fibers inserted into trabeculae of a cribriform plate is the extrusion of posterior teeth following removal of a tooth in the opposite arch. In this case, even when teeth extrude as much as 8 mm or more, radiographic examination reveals that the alveolus follows the tooth. The tooth does not extrude from its socket. Rather, it carries the socket along with it. New bone

growth follows the path of extrusion, possibly accounted for by sufficient stress placed through the periodontal fibers to exert an osteostimulatory effect on the trabeculae of the surrounding cribriform plate.

Biomechanical stress is hypothesized to promote growth in part because bone exhibits the **piezoelectric effect**. When collagen fibers inserted into a trabecula of bone are stressed sufficiently to deform the trabecula, a difference of electric potential is induced and a **bioelectric current** flows.^{61,62} Studies have shown that a net positive electric charge with associated bone resorption is observed at areas of tension within the trabecula as a result of its regional surface deformation. It is in this area that greater than normal numbers of pluripotential cells are found, which differentiate into a preponderance of osteoclasts.^{63,64} A net negative electric charge and associated bone deposition are observed at areas of trabeculae in compression. In these areas, greater numbers of pluripotential cells are found; these differentiate into a preponderance of fibroblastic and osteoblastic bone-forming and remodeling cells.

In the case of trabeculae forming the dental alveolus, or implant alveolus in the osteopreserved mode of implant tissue integration, the surface closest to the tooth or implant exhibits a net negative charge. It is in compression as a result of deformation, which promotes bone deposition. On the other hand, the trabecular surface farthest from the natural tooth or implant exhibits a net positive charge, because it is in tension as a result of deformation, and therefore exhibits resorption.⁶⁵

It is the deposition of bone on the trabecular surface closest to the implant that controls the thickness of the cribriform plate, and thus the thickness of the peri-implant ligament, ensuring stability and long-term function.

The postulated osteogenic effect and bioelectric phenomena also relate to the rapidity of bone regeneration. If bone rebuilds more rapidly around areas of greater negative charge, encouraging limited use of healing fractured bones to induce stress sufficient to increase the negative charge and the rate of cell differentiation generally is recommended to speed regeneration. This logic has led to research and development into devices to supply a negative current to a fractured area to enhance bone formation.^{61,66}

Cell-Generated Biochemical Signals. Osteoblasts are also believed to accumulate around the negative pole of an implanted electrode, because this area's local pH is more alkaline than the usual body pH of 7.4. The functional enzyme of osteoblasts, **alkaline phosphatase (ALP)** works best at this slightly alkaline pH.⁶⁷ It is believed that the ALP produced by osteoblasts breaks down phosphate compounds found in the interstitial fluids, yielding various byproducts including free phosphate. This free phosphate then combines with calcium to form calcium phosphate, an important building block of new bone.

Ground Substance-Generated Biochemical Signals. Fibroblasts and osteoblasts are also responsible for the generation of components of the extracellular matrix that surrounds them.⁶⁸ This material seems to be **amorphous**, composed of a hydrated, semi-solid, gel-like mass that pro-

vides a mechanism for regulating water tissue levels. **Proteoglycans** and **glycoproteins** are present. In all their sub-classifications, they perform many functions, not limited to binding to collagen, regulating growth of collagen fibrils, binding to **fibronectin** and **laminin**, and affecting the attachment, spreading, and migration of cells.

Although the exact mechanisms are not clearly understood, ground substance components, cellular and chemical, are known to influence the rate and quality of healing through generated biochemical signals that intensify following injury and throughout repair.

In the area of research of **ground substance-generated chemical signals**, as with research into cell-generated signals, no breakthroughs have led to developments in clinical protocols to increase the safety and predictability of treatment. The functions of ground substances, although important and influential during tissue repair and long-term maintenance, cannot yet be manipulated to enhance the prognosis of implant treatment.

Effect of Heat Generated by Drilling on Rate and Quality of Bone Healing

Previously in this chapter, the relationship between drill speed and heat generation was discussed. This section discusses the relationship between drill speed and subsequent healing. The rate and quality of healing after drilling osteotomies at low (maximum 2000 rpm), intermediate (maximum 30,000 rpm), and high (maximum 400,000 rpm) speed ranges in the mandible were examined histologically after the heat production measurement protocol described previously. Osteotomies were histologically examined 2, 4, and 6 weeks postoperatively. Histologic findings suggested that in the initial 6 weeks, the rate of healing and quality of new bone formation were higher after high-speed drilling than after low- or intermediate-speed drilling with the drill used in the study. The results of this study contribute further evidence that this type of drill should be used in the high-speed range. As with the heat production measurement protocol, this type of study must be conducted separately for each type of drill to determine optimal drilling speed as it influences heat production and subsequent healing. Together with the results of the heat production protocol, in which a difference of 4.3° C in local temperature was observed among the speed ranges, a possible relationship between heat production and healing is implied for osteotomy drilling.

Relevant Literature. In 1983, Eriksson and Albrektsson¹³ reported that irreversible histologic damage occurred at a temperature of 47° C at durations of heat exposure greater than 1 minute in the rabbit tibia. Although Eriksson and Albrektsson generated heat in bone using an electric coil, they suggested that high-speed drilling could cause physiologic damage to bone. This paradigm was reinforced by the citation of their report in Branemark's textbook and subsequent publications by other authors.

However, abundant literature reports histology that contradicts this conventional wisdom. As early as 1960,

Youngblood⁶⁹ determined that histologic repair increased and the area of the basophilic zone (indicating **necrosis** resulting from the heat of bone drilling) decreased with increasing drill speed up to approximately 300,000 rpm in the canine mandible. Calderwood et al⁷⁰ reported in 1964 that healing was nearly identical after drilling at 10,000 rpm and at 200,000 rpm in the canine mandible. In the same year, Costich, Youngblood, and Walden⁷¹ reported that the smallest area of basophilic staining was observed after high-speed bone drilling in dogs. Also in 1964, Moss⁷² established a viability index of cellular response to bone drilling with respect to the width of the resulting acellular zone, and determined that the detrimental effects of drilling at low speed were the same or more severe than those at high speed in dogs. In 1965, Spatz⁷³ observed less inflammation, a smoother cut edge, and more rapid recovery after drilling at 300,000 rpm than at lower speeds in dogs. In 1966, Boyne⁷⁴ observed no qualitative or quantitative difference in the degree of alveolar ridge healing in dogs 6 weeks after extraction of teeth and removal of the buccal plates of investing bone using low- and high-speed drilling. At high speeds, superior osseous repair was observed 14 days postoperatively with tetracycline labeling. In 1979, Brunski et al²⁹ demonstrated direct bone-to-implant interface with no evidence of necrosis following insertion of one-stage hypofunctional blade implants into osteotomies prepared using 700 XL burs at high speed with external water coolant.

The controlled study described here was the first that serially evaluated the histologic healing response following dental implant osteotomy preparation at controlled speed ranges.

Results. The histologic observations in the study by Iyer, Weiss, and Mehta⁷⁵ were consistent with those reported by Calderwood et al⁷⁰; Costich, Youngblood, and Walden⁷¹; Moss⁷¹; and Boyne,⁷⁴ indicating that high-speed drilling within the range of 250,000 to 400,000 rpm results in an enhanced rate of initial healing and maturation of bone. At 6 weeks, no specimen prepared at any speed showed macroscopic evidence of prior osteotomy preparation. Microscopically, the rate and degree of bone formation and maturation were observed to improve substantially with increasing drill speed.

At 2 weeks, the high-speed specimen (maximum 400,000 rpm) showed the greatest amount of woven bone (Fig. 5-10, A), whereas in the intermediate (maximum 30,000 rpm) (Fig. 5-10, B) and low-speed (maximum 2000 rpm) specimens (Fig. 5-10, C) only negligible quantities of osteoid were observed. The low-speed specimen showed evidence of necrotic tissue.

At 4 weeks, the degree of maturation of the newly formed bone was observed to have increased considerably in the high-speed specimen (Fig. 5-10, D), whereas the intermediate (Fig. 5-10, E) and low-speed specimens (Fig. 5-10, F) showed evidence that transformation of the osteoid into woven bone had begun, with only traces of mature bone.

At 6 weeks, the high-speed specimen showed the greatest degree of maturation into dense, compact bone (Fig.

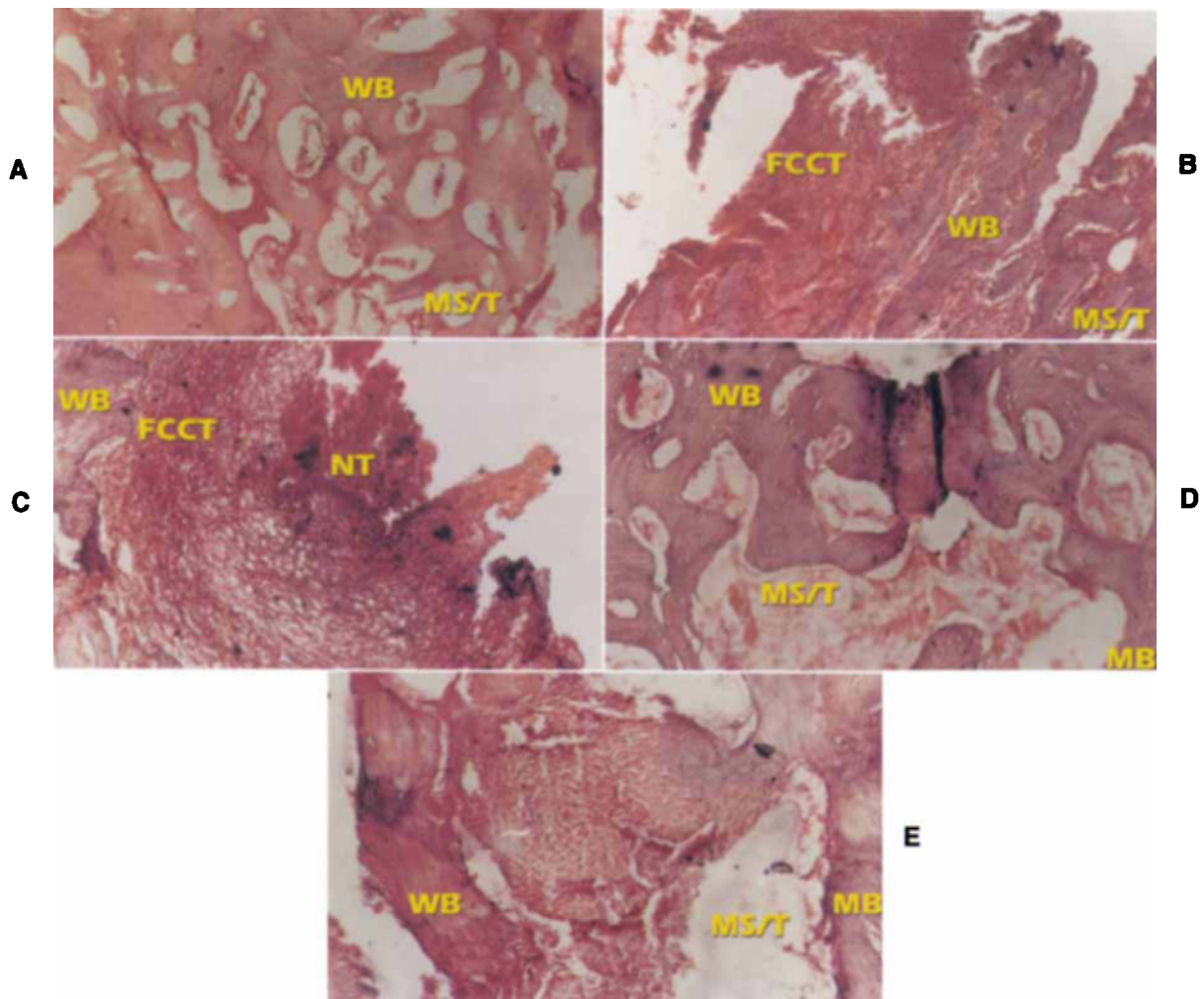


FIG. 5-10 ■ A, Two weeks postoperative histology after high-speed drilling (200,000 to 300,000 rpm). WB, Woven bone; MS/T, Marrow space tissue. B, Two weeks postoperative histology after intermediate-speed drilling (maximum 30,000 rpm). FCCT, Fibrocellular connective tissue; WB, Woven bone; MS/T, Marrow space tissue. C, Two weeks postoperative histology after low-speed drilling (maximum 2000 rpm). WB, Woven bone; FCCT, Fibrocellular connective tissue; NT, Necrotic tissue. D, Four weeks postoperative histology after high-speed drilling (200,000 to 300,000 rpm). WB, Woven bone; MS/T, Marrow space tissue; MB, Mature bone. E, Four weeks postoperative histology after intermediate-speed drilling (maximum 30,000 rpm). WB, Woven bone; MS/T, Marrow space tissue; MB, Mature bone.

Continued

5-10, G). The intermediate (Fig. 5-10, H) and low-speed (Fig. 5-10, I) specimens showed moderate amounts of compact bone and large marrow spaces.

Similar healing rates were observed between the intermediate- and low-speed osteotomies. Although the low-speed osteotomy showed the least healing after 2 weeks, the intermediate-speed osteotomy showed the least healing after 4 weeks. However, at every observation time, the high-speed osteotomy showed the greatest degree of repair and the highest quality of new bone.

Possible Causes of Differences in Rate and Quality of Healing at Different Drilling Speeds. The primary cause of the observed difference in bone healing is speculated to be the difference in heat production at each

experimental drill speed range. Published abstracts related to a study in dogs funded by the National Institutes of Health have shown no statistically significant difference between the percentage of direct bone apposition against plate/blade forms and root forms after 6 months of unloaded healing when the osteotomies were prepared at comparably low temperatures but with different drilling protocols.³¹ These findings agree with those of the present study, suggesting that the selection of the configuration and interface texture of an implant are less important to healing than the maintenance of low temperatures during osteotomy drilling, as well as those of Sisk et al.,⁷⁶ who compared osteointegration of six implant types in dogs. It is interesting to note that the difference in the quality and

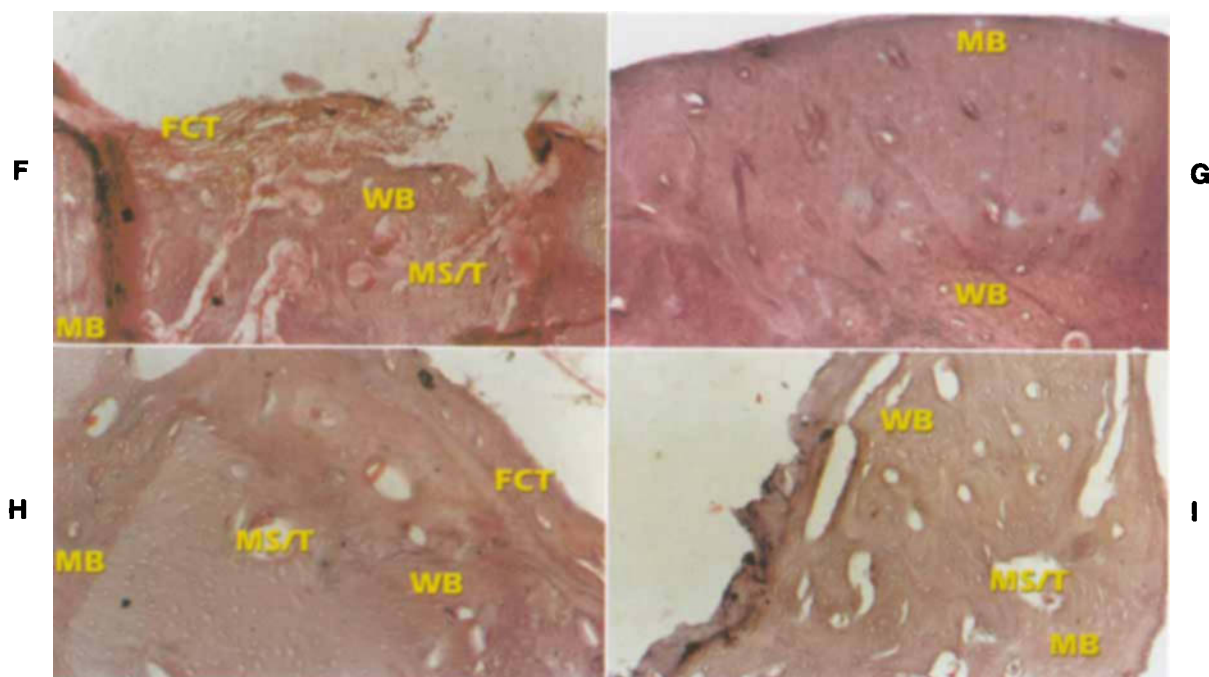


FIG. 5-10, cont'd ■ F, Four weeks postoperative histology after low-speed drilling (maximum 2000 rpm). *MB*, Mature bone; *FCT*, Fibroconnective tissue; *WB*, Woven bone; *MS/T*, Marrow space tissue. **G**, Six weeks postoperative histology after high-speed drilling (200,000 to 300,000 rpm). *MB*, Mature bone; *WB*, Woven bone. **H**, Six weeks postoperative histology after intermediate-speed drilling (maximum 30,000 rpm). *MB*, Mature bone; *MS/T*, Marrow space tissue; *WB*, Woven bone; *FCT*, Fibroconnective tissue. **I**, Six weeks postoperative histology after low-speed drilling (maximum 2000 rpm). *WB*, Woven bone; *MS/T*, Marrow space tissue; *MB*, Mature bone.

rate of healing after osteotomy preparation at each drilling speed was considerable, although the temperature differential observed was only 4.3° C.

The shock waves generated and transmitted into living tissue by the torque, speed, and vibration of the drill are another factor that may partially account for the observed differences in the rate and quality of bone healing. Such shock waves have been shown to destroy osteocytes and odontoblasts below the cutting surface of the drill, resulting in a lower rate and quality of healing. The shock waves produced under low-speed drilling, commonly thought to be of a greater magnitude than those produced under high-speed drilling, are speculated to be partially responsible for the lower rate and quality of healing observed after low-speed osteotomy preparation.¹⁸

A third possible factor is that the cut margins of the bone in osteotomies prepared under low speed are jagged. Undernourished bone projections must physiologically resorb before healing can occur. On the other hand, the cut margins of bone in osteotomies prepared with high-speed drilling have histologically been shown to be smoother.⁷³ Thus, less resorption occurs, allowing appositional healing to begin faster.

Additional research is required to determine whether heat production, evacuation of heated bone, shock waves, surface topography of the cut edge, or any combination of these fac-

tors is responsible for the different healing rates observed after osteotomy preparation at different drilling speeds. In particular, repeating the prescribed protocol using cooled water to further reduce tissue temperature before and during osteotomy preparation would help to clarify any relationship between temperature and healing.

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6 Tissue Integration at the Implant Interface

Tissue integration at the interface of healed functioning dental implants occurs in three possible modes. Before examining mainstream step-by-step treatment, it is important to know what these three modes are, and how they differ. The practitioner determines and controls the mode of tissue integration. Most often careful consideration suggests one mode to be the best choice for the case at hand, and less often the practitioner, in consultation with the patient, must choose from among the three modes when the mainstream applications of different implant modalities overlap.

Dental implant practitioners say that a successfully healed implant has “integrated.” It produces a ringing sound when tapped with an instrument. It appears to be firm and solid, the soft tissue around it is visibly healed, and it is ready to be used as an abutment. However, this is not a sufficient understanding of tissue integration. In the clinic, integrating tissues cannot be observed at the cellular level, nor can the percentages of each type of tissue or their physical distribution around the interface be ascertained. However, such considerations are very important. They are what comprise the mode of integration around the implant, which in turn dictates how the integrated abutment must be handled prosthodontically.

The three modes of tissue integration around healed dental implants are osteointegration, osteopreservation, and periosteal integration. Each is proven safe and effective (see Controversy box). The same tissues are present at the interface of all endosteal implants, regardless of the mode of tissue integration. Vascular and neural tissues are present,^{1,2} but the primary tissues are cortical and cancellous bone, marrow, and collagenous fibers.³ The percentages of each tissue type and their distribution at the implant interface differ between the two modes of endosteal tissue integration. One must have a basic understanding of how to select the most appropriate mode of tissue integration for a given case and of how to cause it to occur. One must also understand how the biomechanics of each mode of tissue integration profoundly affect not only diagnosis and treatment planning but also the restoration and even the long-term prognosis.

Practitioners must be familiar with each of the three modes of tissue integration, including treatment protocols and restorative parameters, or be prepared to refer a case

CONTROVERSY

The Existence of Three Modes of Tissue Integration

As a rule, practitioners who favor the exclusive use of the root form modality maintain that osteointegration is the only viable mode of tissue integration and that any physiology other than a preponderance of direct bone apposition at the implant interface represents pathology or failure. Nonetheless, the existence of a nonpathologic peri-implant ligament that functions in health long-term around one-stage plate/blade form implants, endodontic stabilizers, and most orthopedic implants is a known fact. The confusion may stem from extrapolation to implants of other modalities of the fact that the absence of direct bone apposition around conventional root forms represents failure. Such extrapolation is mistaken. Furthermore, the mode of tissue integration observed around a subperiosteal implant, which is placed against and not within bone, cannot logically be the same as that observed around either endosseous modality. This chapter carefully examines the physiology, biomechanics, and clinical considerations associated with each of the three modes of tissue integration.

to a more experienced practitioner if an unfamiliar mode of tissue integration is called for.

GENERAL PRINCIPLES

Biomechanics

Understanding basic biomechanics is essential to understanding the parameters of each mode of tissue integration. Stress is equal to force divided by the area over which it is applied. In dental implantology, the force applied is functional load. Therefore, given a functional load, increased interface area (i.e., the area over which the force is applied) of the implant reduces resultant mechanical stress. For this reason, maximizing the use of available bone is considered beneficial. To every action there is an equal and opposite reaction. As occlusal load (an axial force) is applied, it passes through the body of the implant as mechanical stress that subsequently is passed to the tis-

sue interface. These tissues respond in an equal and opposite direction, with various physiologic consequences. When implants or teeth fail because of **hyperfunction**, the cause usually is bone resorption that occurs as a result of applied stress that exceeds bone's physiologic limits of health. Implant or tooth failure typically is not due to failure of the implant or tooth per se, in terms of fracture. An implant fails when sufficient surrounding bone fails and is replaced by a nonosteostimulatory collagenous fiber zone that progressively widens.

Duty Cycle

Understanding the **duty cycle** of mechanical force as it relates to teeth and osteopreserved, osteointegrated, and periosteally integrated implants in terms of resistance, damping, and the physiologic limits of health of the investing tissues is important when assessing prognosis. Consider a functional force applied to two teeth over a given period. Tooth A is ankylosed, and tooth B has a normal periodontal membrane (Fig. 6-1). In tooth B, the given force of occlusion has a substantially lower peak magnitude that is dissipated over a longer period, because of the **shock absorption** and damping effects of the periodontal ligament.⁴ The force over time curve of tooth A shows that the same applied force of occlusion peaks at a substantially higher level and is dissipated over a shorter period because of the absence of the shock-absorbing and damping effects of a membrane.

Physiology of the Periodontal Ligament and Dental Alveolus

A review of the physiology and anatomy of the periodontal membrane and dental alveolus helps in understanding the physiology and anatomy of the peri-implant ligament and its surrounding cribriform plate (alveolus) and associated structures for osteopreserved implants.

The anatomy of the periodontal ligament depends in part on the frequency, magnitude, rate, direction, and duration of applied forces.⁵ Intermittent masticatory loads of substantial magnitude increase membrane width and the number and density of the principal collagenous fibers, with little positional change. Forces of lower magnitude over longer duration cause positional change of the collagenous fibers, until a new condition of equilibrium is established.⁶ Physiologic rest position is lips together, teeth apart. Normally, teeth touch only during chewing, swallowing, and rarely during various other movements, producing essentially axial forces. In addition, essentially horizontal forces from the tongue, lips, and cheek are applied. The normal periodontium may not be able to accommodate a change in the usual applied forces that is too great or too rapid, and pathologic changes may result.⁶

The principal collagen fiber bundles comprise up to 75% of the volume of the periodontal membrane.⁷ They are short and pass from insertions in cementum into insertions in trabeculae of the cribriform plate. Because collagen is ori-

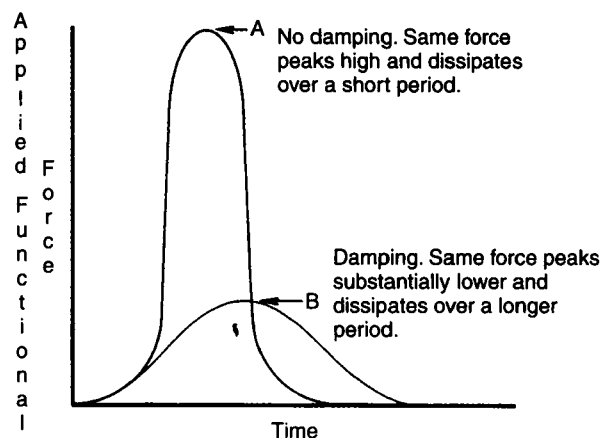


FIG. 6-1 ■ Duty cycle. Stress absorption over time of ankylosed tooth (A) and normal tooth (B) with periodontal ligament.

ented along lines of tension, these bundles have been shown to resist axial loads applied to the alveolus, while crestal fibers are oriented along force vectors that are essentially horizontal.⁸ Because of its anatomy and fluid-filled regions, the membrane zone also influences compressive forces. Teeth exhibit membrane widths between 150 and 300 μm . The waviness (kinked nature) of unstressed collagen fibers in the membrane suggests that a certain amount of movement of a tooth root is required for application of axial load sufficient to pull the fibers taut and stimulate trabeculae of bone in the cribriform plate.

Anatomically there are many openings of various sizes in the cribriform plate within the alveolus. Because the membrane contains and is bathed in fluids, compression of the ligament forces fluids through internal openings in the cribriform plate and into the marrow spaces beyond, creating a hydraulic damping effect. This same effect is caused by the presence of blood vessels, which occupy a small percentage of the membrane space. Blood is forced out of regions under compression and into other areas of the vessels and other interconnected vessels. Therefore, vessel size increases apically. Also, venous sinuses are located at root bifurcations and at the apex. These and numerous other capillary loops and shunts combine to provide additional hydraulic damping as applied force is transmitted and absorbed.⁹ The tensile plus compressive **hydraulic effects** combine to modify, redirect, and absorb functional forces. They permit the supporting tissues to absorb intra-oral forces of substantial magnitude, in many directions, within physiologic limits of health. Collagen fibers provide resistance to tooth root displacement by transmitting stress to the alveolus. In regions of mechanical loading, all fibers, cells, and blood vessels transmit mechanical stress to the alveolus.¹⁰

Ankylosed teeth have reduced mobility and are not protected by the viscous-type damping of a membrane. Forces are transmitted directly to bone. Thus, ankylosed teeth show a nearly linear relationship between force and displacement. They are supported by bone with a high relative modulus.

Teeth in Function

Teeth assume an extruded position in the absence of occlusal contact, such as during sleep and when the mouth is open. This extrusion probably is limited by the apical and crestal fibers of the periodontal membrane. During mastication, teeth assume a more intruded position, with increased loading time. This represents a state of static pseudo-equilibrium. In addition, pulsatile movements of the tooth can be detected.¹¹ These rhythmic displacements are caused by and are synchronous with the heartbeat and local blood flow, and are microscopic events.

Axial, horizontal, and tangential **force components** all are resisted by the supporting tissues. Initial and small forces produce a relatively large amount of relative movement. As a load is slowly increased, less relative displacement is observed. The initial displacement of the root caused by small-force magnitudes occurs because the soft tissues and fluid elements of the membrane easily move relative to one another, and collagenous tissues exhibit two distinct ranges of modulus. With slowly increasing force, increasing numbers of collagen fibers are loaded axially in tension and resist root displacement by transferring stress to the alveolus. In regions of compression, all the fibers, cells, and blood vessels are subjected to localized compressive or hydraulic loads, which are transmitted to the alveolus. The tension state is the most important consideration within this context. Following initial displacement, at which time the slack in the kinky collagen bundles becomes taut, tension deforms the trabeculae of the alveolus, resulting in a net bioelectric and biochemical change within the trabecular surface facing the root. This action is postulated to result in an osteostimulatory piezoelectric effect.¹²

Removal of force causes the tooth and supporting tissues to return to positions of equilibrium. Collagen fibers are largely responsible for the elastic response properties of the membrane. In addition, ground substance is also an important part of the viscoelastic aftereffect when a tooth is loaded and unloaded mechanically.⁵

OSTEOINTEGRATION

Definition

Osteointegration is the mode of tissue integration around a healed functioning endosteal implant in which the prime load-bearing tissue at the interface is bone.

Applicability

Osteointegration is the only mode of tissue integration with which the root form modality can succeed. If direct bone apposition at the interface of a root form is insufficient, fibrous tissue percentages progressively increase and implant removal may be required.

Osteointegration can also succeed when using the plate/blade form modality, yielding percentages of direct bone apposition at least as high as those observed around root forms.¹³ More often, though, practitioners choose os-

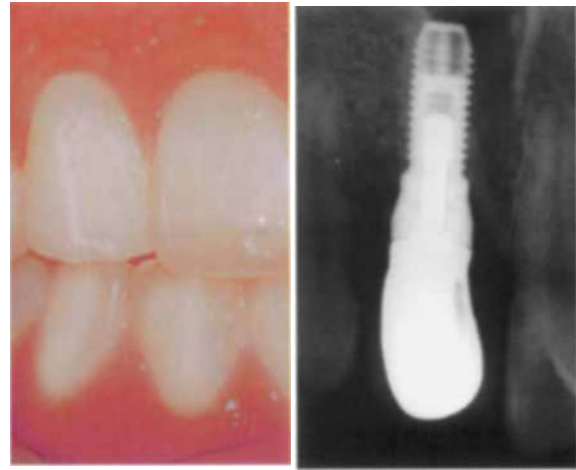


FIG. 6-2 ■ Root form-supported single tooth replacement.



FIG. 6-3 ■ Root form-supported multiple tooth replacement.

teopreservation as the mode of tissue integration when using plate/blade form implants.

In mainstream cases, osteointegrated implants usually are not joined to natural co-abutments. Root forms can support individual crowns (Fig. 6-2) and can be splinted to each other or used separately as sole support for a partial (Fig. 6-3) or complete arch prosthesis (Fig. 6-4).

Achieving Osteointegration

Given correct diagnosis, treatment planning, and surgical insertion of the implant, the key to achieving osteointegration is appropriate case sequencing and afunctional

healing. Stress passed through the implant during healing creates stress-generated bioelectric signals, as well as cell- and ground substance-generated chemical signals, which modify the character of the healed interface in ways not yet completely understood. Maintenance of an afunctional condition slows the rate of healing, which otherwise proceeds normally, affecting the case sequencing by increasing total elapsed treatment time of the case. Initial loading of the healed implant generally is advised to occur between 3 to 6 months in the mandible, and 6 to 9 months in the maxilla^{14,15} (see Controversy box).

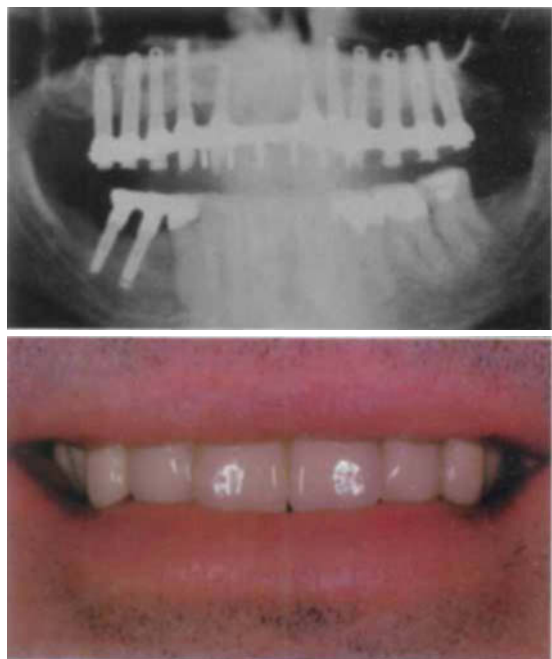


FIG. 6-4 ■ Root form–supported maxillary complete arch fixed prosthesis.

CONTROVERSY

Immediate Loading of Root Form Implants

It is widely known that root form implants require osseointegration to succeed in function. For the physiologic and biomechanical reasons described herein, this requires that root form implants heal in the absence of micromovement, either by following the submerged or the semi-submerged healing protocol.

Recently, manufacturers and clinicians have focused their efforts on the possibility of immediately loading root form implants, rather than allowing them to heal afunctionally. Most immediate-loading root forms are intended to be put into function 8 weeks after insertion, and have a sandblasted, large-particle, acid-etched interface. Benefits of immediate loading, as with osteopreserved implants, include a substantial reduction in total required healing time.

Proving that immediate loading of root form implants can be performed successfully, resulting in long-term success and not compromising the physiology or biomechanics of the im-

plant and host site, will be an important breakthrough in root form treatment. However, it should be understood that immediate loading is unconventional precisely because afunctional healing is required to achieve osseointegration. Therefore, immediate loading of root forms cannot be considered a mainstream treatment protocol until such time as its long-term safety and efficacy have been demonstrated.

Physiology

Distribution of Cortical/Cancellous Interface. Because root form and plate/blade form implants can both osseointegrate, but are different in basic shape, separate examination of the cortical/cancellous interface distribution is required for each. Common to each is the character and distribution of cortical and cancellous bone found at the host site. The mandible exhibits a higher percentage of cortical bone than does the maxilla, higher anteriorly than posteriorly.

Consider a mandibular posterior implant host site 10 mm in depth and 24 mm in mesio-distal length. Three conventional root forms of 3.5 mm in diameter can be inserted, in which case the bucco/labio-lingual width of the ridge crest should be at least 5.5 mm to allow for 1 mm of bone on the buccal and lingual of the implant at insertion. Treatment can also be offered using a single plate/blade form of 1.35 mm width and 24 mm length, in which case

plant and host site, will be an important breakthrough in root form treatment. However, it should be understood that immediate loading is unconventional precisely because afunctional healing is required to achieve osseointegration. Therefore, immediate loading of root forms cannot be considered a mainstream treatment protocol until such time as its long-term safety and efficacy have been demonstrated.

The design of root forms intended for immediate loading must account for the physiology and biomechanics of osseointegration and how it is conventionally achieved, and cases in which the immediate loading protocol is attempted should be as close to ideal as possible, particularly when conducting the clinical trials necessary to establish long-term safety and efficacy. A key to accomplishing this goal may be the design of an interface that permits the osteopreservation of root form implants placed into early function.

the bucco-lingual width of the ridge crest should be at least 3.35 mm to allow for 1 mm of bone on the buccal and lingual of the implant at insertion.

The cortical/cancellous interface of each of the three root forms or the single plate/blade form that occupies the same mesio-distal length of available bone in this model are compared as follows. At the mesial and distal of each of the three inserted root form and the single plate/blade form implant, there is almost 100% cancellous bone apposition. Macroscopically, the root form implants have 50% cortical bone and 50% cancellous bone at the buccal/labial and lingual interfaces, because in bucco-lingual cross-section, the mandible widens from crest to base. Thus, each root form exhibits approximately 25% cortical contact and 75% cancellous contact at the time of implant insertion. Because of the basic shape of the plate/blade form implant, it has substantially more cortical bone apposition buccally and lingually after insertion into the osteotomy. In total, the plate/blade form exhibits approximately 50% cortical contact and approximately 50% cancellous contact at the time of insertion in this model.¹⁸ Thus, in this analysis, the single osteointegrated plate/blade form implant has greater than 150% more cortical contact than the total cortical contact of the three root form implants (Fig. 6-5).

The percentages in this exercise represent macroscopic interface area. The percentages of actual direct bone apposition of each tissue in function is determined by analysis of the microanatomy along the entire implant/tissue interface.

Optimizing cortical contact at the interface at the time of insertion may be advantageous. Edentulous alveolar ridges commonly vary in bucco/labio-lingual width; consequently, various diameters of root form implants are available to maximize cortical contact.

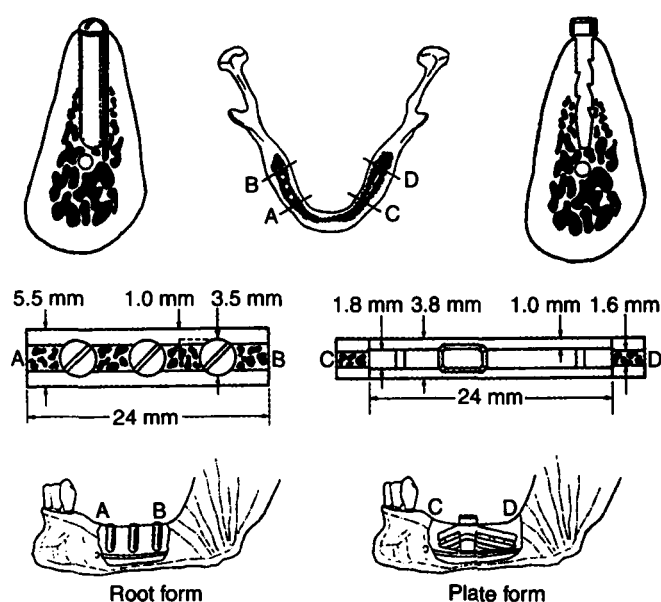


FIG. 6-5 ■ Comparative analysis of cortical and cancellous bone apposition opposite the interface of three root forms or one plate/blade form implant in 24-mm length and 10-mm depth of available bone.

Under clinical evaluation is the “Chiarenza Concept,” in which a unique root form and plate/blade form combination design is used.¹⁹ The implants are rectangular in cross-section, either 1.8 mm or 3.0 mm in width and 7 mm in length. They are placed serially (Fig. 6-6) to simulate mandibular molar root configurations, in which the bucco-lingual dimension is greater than the mesio-distal dimension (Fig. 6-7). In wide ridges, the 7-mm “length” is placed bucco-lingually across the crest, or in cases in which the crest is slightly narrower, the implant length is positioned obliquely to ensure maximal contact with both cortical plates. In narrow ridges, these implants may be placed conventionally (Fig. 6-8).

The Chiarenza Concept is available as a two-stage system for osteointegrated healing (Fig. 6-9) or as a one-stage system for osteopreserved healing (Fig. 6-10).

Microanatomy. At the electron microscopy level, very little or no direct bone apposition appears to be present at the interface of an osteointegrated implant.²⁰ Ground substance, mucopolysaccharides, some fibrous tissue, and other substances are present between the interface and bone.²¹ Clinically, the thickness of this layer of substances is minute. Biomechanically, for all practical clinical considerations, bone apposition is direct.

The concept that osteointegration represents 100% bone direct apposition is incorrect. It has been estimated

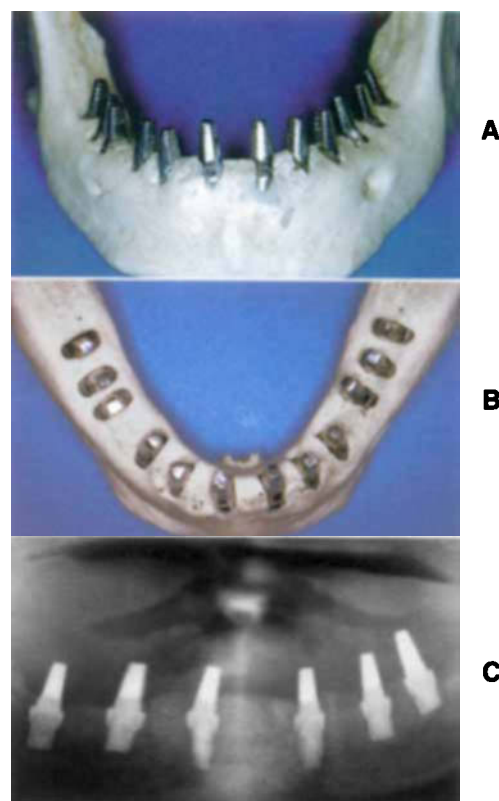


FIG. 6-6 ■ Anterior (A), occlusal (B), and radiographic (C) views of serial placement of combination plate/blade and root form implants in mandible.



FIG. 6-7 ■ Bone dissection showing narrow anterior-posterior and wide bucco-lingual configuration of mandibular molar roots.

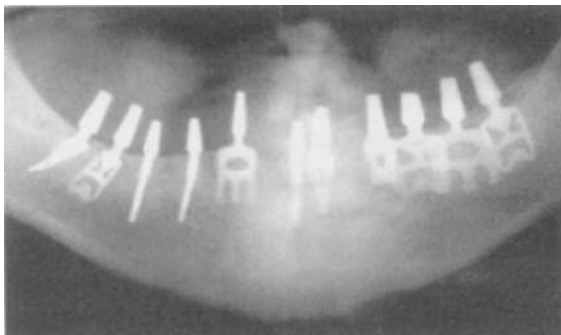


FIG. 6-8 ■ Radiograph showing bucco/labio-lingual, mesio-distal, and oblique placement of combination root form and plate/blade form implants according to variation in ridge width along the arch to achieve maximum cortical contact.



FIG. 6-9 ■ Radiograph of two-stage combination root form and plate/blade form implants placed interdental and distally for osteointegration.

that as little as 20% actual direct or real bone contact at the light microscopic level, properly distributed at the implant interface, can constitute osteointegration.²² The average is approximately 35.6% actual direct bone contact.²³ The remainder of the interface is made up of marrow and fibrocollagenous tissues (Fig. 6-11). Researchers have reported

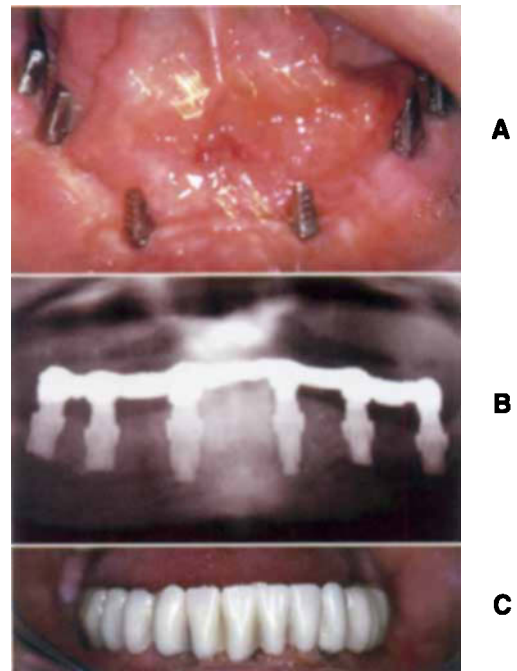


FIG. 6-10 ■ One-stage combination root form and plate/blade form implants supporting a complete arch fixed restoration. Healed implants (A), radiograph of splinted coping/retention bar mesostructure cemented in position (B), and seated acrylic semi-fixed flangeless overdenture (C).

substantial histologic variation in animal and human studies of retrieved functioning implants.

Direct bone-to-implant contact has also been proposed to occur at the ultrastructural level with the interposition of a minute thickness of non-bone substances (Fig. 6-12). Portions of the bone adjacent to some osteointegrated implants are relatively adherent at the interface and sometimes cannot be separated from the implant interface without damaging tissue.²⁴ Haversian systems have been identified regionally and occupy bone that extends within screw threads. Parallel and interstitial lamellae are present together with cement lines, suggesting active remodeling in response to applied force.²⁵

Shock Absorption/Duty Cycle. The osteointegration mode of tissue integration is limited in its capacity to dampen rapidly applied loads. As a result of the modulus of elasticity and structural character of bone into which the inserted implant has become osteointegrated, some deformity can occur as functional forces are applied. Bone has limited viscoelastic capacity, offering only a small amount of protection against breakdown at the interface when substantial loads are applied. In cases in which added shock absorption is desirable, the **restorative practitioner** can use an array of materials more forgiving than porcelain to mitigate shock and alter the duty cycle.²⁶

Stress Distribution. Three-dimensional finite element computer analysis has shown that the bulk of mechanical



FIG. 6-11 ■ Histology of osteointegrated root form. Note marrow spaces, some fibrous tissue, and lacunae.

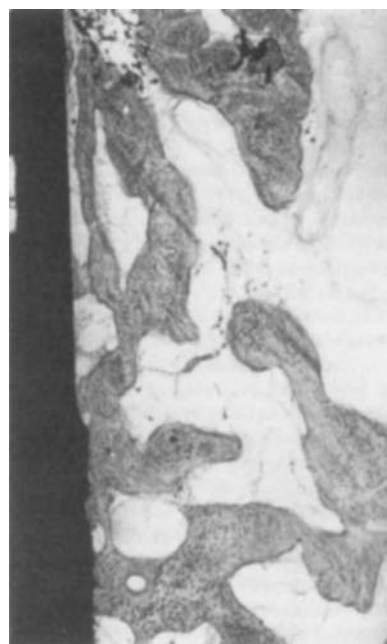


FIG. 6-12 ■ Histology of osteointegrated root form. Note minute thickness of non-bone substances. (From Misch CE, editor: *Contemporary implant dentistry*, ed 2, St Louis, 1999, Mosby.)

stress usually is passed to the integrating tissues along the crestal 20% of the implant.²⁷ This varies with the degree of slip at the interface in the model, where slip represents movement with zero friction in shear, and no-slip represents zero relative movement in shear.²⁸

Note again that stress is determined by dividing the applied functional force by the interface area over which it is applied. Thus, at each point on the interface, stress is reduced if the actual interface area is, for example, 45% direct bone apposition rather than 30%. This has a direct bearing on long-term prognosis.

Mobility. A successfully osteointegrated implant exhibits zero intraoral mobility. In the presence of even slight intraoral mobility, an osteointegrated root form may be considered to have a complication. In the case of a plate/blade form, minor mobility may represent the formation of an osteostimulatory peri-implant structure, and a transition from osteointegration to osteopreservation. Lack of mobility is considered a prime asset of osteointegration.

Biomechanical Considerations

Biomechanical considerations related to osteointegration are less complex than those related to nonankylosed teeth and osteopreserved implants, which have ligaments that act as shock absorbers to protect investing bone. Osteointegrated implants lack a peri-implant ligament. They are therefore analogous to ankylosed teeth, although with a smaller percentage of direct bone apposition.

The condition of direct bone apposition substantially influences prosthodontic restoration. An osteointegrated implant may not be treated as if it were a tooth, and in mainstream cases is rarely joined to natural co-abutments under a prosthesis. The resilience of a natural co-abutment caused by its periodontal ligament imparts a cantilever effect to the osteointegrated implant, subjecting it to unfavorable forces that can lead to failure of the implant, the prosthesis, or both. In the case of root forms, the advantage of not having a peri-implant ligament is that they can be used for single-tooth replacement, and that their use does not require co-support with natural co-abutments under a prosthesis, allowing the practitioner to leave healthy and esthetic adjacent teeth untouched.

All abutments supporting an overlying restoration should have biomechanically equivalent tissue integration. Because natural co-abutments exhibit a normal amount of resilience as a result of the presence of the osteostimulatory periodontal membrane, osteointegrated endosteal implants generally should not be used as co-abutments with natural teeth in mainstream cases. A complete arch prosthesis can be supported entirely by osteointegrated implants.²⁹ One or more unilaterally placed free-standing osteointegrated or osteopreserved plate/blade forms are not recommended as sole support for an overlying prosthesis. One or more osteointegrated root forms placed unilaterally can support an overlying prosthesis of free-standing or splinted crown restorations. This is an additional benefit of using osteointegrated root forms.

OSTEOPRESERVATION

Definition

Osteopreservation is the mode of tissue integration around a healed functioning endosteal dental implant in which the prime load-bearing tissue at the interface is a peri-implant ligament composed of osteostimulatory collagen fibers that diminish the functional force passed to the surrounding bone.³⁰

This book uses the term *osteopreservation* because endosteal implants functioning with this mode of tissue integration preserve alveolar bone that would have resorbed if the case remained unimplanted, and comparison of the results of clinical trials indicates that at equal reported time intervals, osteopreserved implants exhibit bone maintenance comparable or slightly superior to that around osteointegrated implants.^{31,32} Hence, they “preserve” the alveolar ridge.

Historically, in implant dentistry the term **fibro-osseointegration** has been applied both to plate/blade form and subperiosteal implants (see Controversy box). However, the modes of tissue integration around these two implant modalities are not the same. The integration observed around any functioning endosteal implant is clearly different from that observed around functioning subperiosteal implants, which are placed against rather than within bone. Although many of the biomechanical considerations related to osteopreservation and periosteal integration, the tissue integration of subperiosteal implants, are similar, their physiology, anatomy, required healing sequence, and maintenance requirements differ. Therefore, differentiation between these two modes of tissue integration is required. Throughout this book, the term *osteopreservation* is applied to endosteal implants that successfully function with an osteostimulatory peri-implant ligament, and the term *periosteal integration* is applied to the mode of integration around subperiosteal implants. The periosteal mode of tissue integration is discussed in the following section.

As opposed to the term *fibro-osseointegration*, the term *osteopreservation* is not a derivation of the term *osteointegration*,

and therefore does not imply that this type of integration is an offshoot or variation from the norm. Osteopreservation has been in continuous general usage longer than any other mode of tissue integration, and its safety and efficacy have been demonstrated by some of the finest clinical trials ever conducted in implant dentistry.³³⁻³⁵

Applicability

Osteopreservation is the most commonly used mode of tissue integration for the plate/blade form modality. In complete arch cases in which the restoration turns the arch, osteopreserved implants can act as sole support for an overlying fixed (Fig. 6-13) or semi-fixed prosthesis (Fig. 6-14). Unilaterally, osteopreserved plate/blade forms are joined to one or more natural co-abutments as support for a fixed restoration (Fig. 6-15). Because of their thin width and wide range of configurations, plate/blade form im-

CONTROVERSY

The Difference Between Osteopreservation and Periosteal Integration

Historically, the literature has used the term *fibro-osseointegration* as a blanket term to cover the modes of tissue integration around endosteal one-stage plate/blade form implants and subperiosteal implants. Because an endosseous implant is placed within bone and a subperiosteal implant against bone, their modes of tissue integration cannot be the same. This book uses the term *osteopreservation* for the mode of tissue integration observed around one-stage plate/blade forms and *periosteal integration* for that around subperiosteal implants. This is done to provide much-needed differentiation for the two modes, which are physiologically distinct.

FIG. 6-13 ■ Plate/blade form-supported mandibular complete arch fixed prosthesis.



plants can be used in most healed partially and totally edentulous alveolar ridges (Fig. 6-16).

Osteopreservation is also the mode of tissue integration for threaded endodontic stabilizers, which are inserted to functionally lengthen roots of compromised teeth to enhance prognosis (Fig. 6-17). Unlike plate/blade forms, endodontic stabilizers cannot heal afunctionally to achieve osteointegration, because the teeth through which they are inserted exhibit normal micromovement in function.

In addition to its applications in implant dentistry, osteopreservation is the mode of tissue integration used for most endosteal medical orthopedic implants of all types.^{29,36}

Achieving Osteopreservation

The key to achieving osteopreservation is appropriate case sequencing and hypofunctional healing. During healing, limited functional forces pass through the implant to alter the stress-generated conditions that influence the character of the healed interface.³⁷

Hypofunction allows healing to proceed quickly. More rapid healing in turn shortens case sequencing and elapsed time in treatment. Although the soft tissue overlying the osteotomy generally heals in 2 weeks, healing of the tissues

associated with the implant interface occurs more slowly, during which time the overlying prosthesis is completed and cemented into position. **Progressive loading** then proceeds over time, and the implant passes from a hypofunctional condition to full function. Long-term remodeling and maintenance occurs in response to function³⁸ (Fig. 6-18).

Hypofunctional healing is controlled by the implant abutment, which protrudes into the oral cavity on the day of insertion. Osteopreserved one-stage plate/blade forms are supplied with the abutment integral with the implant body as one contiguous piece (Fig. 6-19). Abutments are adjusted for adequate interocclusal clearance and parallelism at the time of insertion. Posteriorly, the location of most mainstream plate/blade form cases, the abutment is not in an esthetic area, and therefore no provisional restoration is required. The abutment is out of occlusion, and thus in hypofunction. The patient is instructed not to chew anything in that area. Only the tongue and cheek contact the abutment. More anteriorly, when esthetic considerations require the use of provisional teeth, they are adjusted to be slightly out of occlusion over the implant and natural co-abutments. The patient is instructed to maintain a soft diet and diligent home care. The final prosthesis

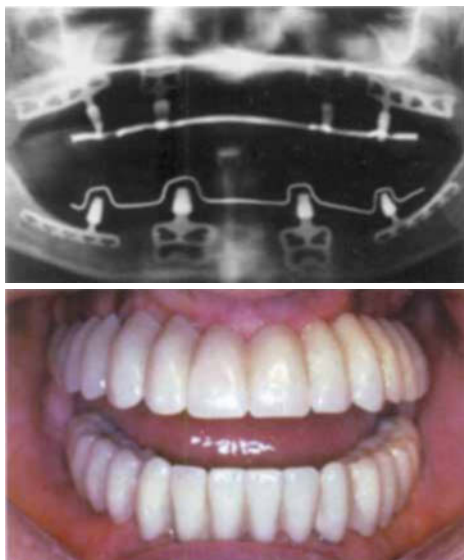


FIG. 6-14 ■ Plate/blade form-supported maxillary and mandibular complete arch semi-fixed prostheses.

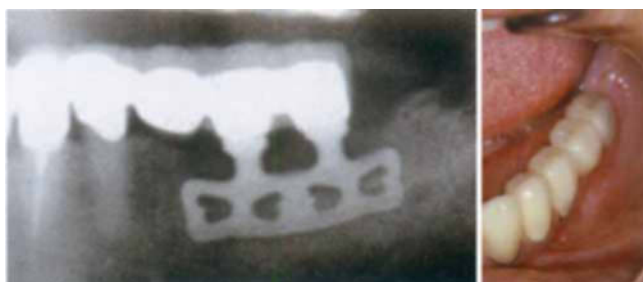
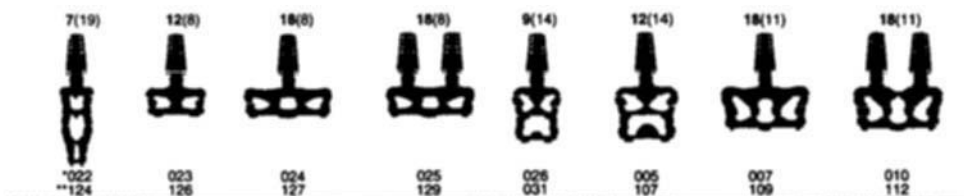
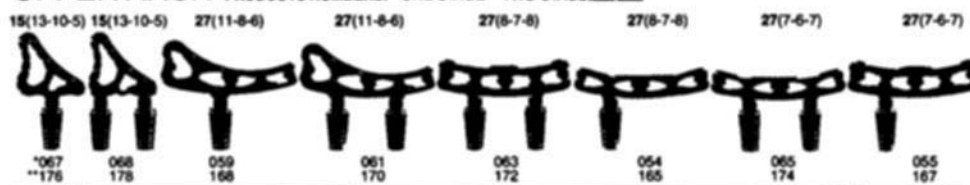


FIG. 6-15 ■ Plate/blade form with natural co-abutments supporting a fixed prosthesis.

EITHER ARCH

PRODUCTS NUMBERS: *ONE STAGE **TWO STAGE 

UPPER ARCH

PRODUCTS NUMBERS: *ONE STAGE **TWO STAGE 

LOWER ARCH

PRODUCTS NUMBERS: *ONE STAGE **TWO STAGE 

MM DIMENSION NUMBERS (ABOVE IMPLANTS)

BOLD TYPE: mesiodistal implant length

Numbers in parentheses

1" = medial implant + depth from ridge crest

2" = central implant + depth from safety stop at ridge crest

3" = distal implant + depth from ridge crest

*Central depth numbers only used for symmetrical implants

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Generation
Ten*
BLADE FORM
SELECTOR

ORAGT 90-015

FIG. 6-16 ■ Various configurations of plate/blade form implants to maximize use of available bone. (Courtesy Oratronics, Inc.)

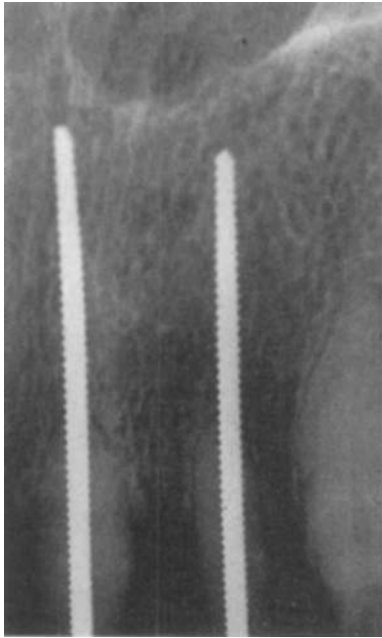


FIG. 6-17 ■ Endodontic stabilizers in osteopreservation mode of tissue integration.



FIG. 6-18 ■ Densely packed trabeculae of healed functioning cribriform plate adjacent to osteopreserved plate/blade form implant.

is fabricated and cemented as quickly as possible, usually within 6 to 8 weeks postinsertion, in mainstream osteopreservation cases.

At the time of final cementation, the bone is still healing and the peri-implant ligament still forming. The implant, which was clinically immobile at the time of insertion because of direct **frictional fit** within the osteotomy, remains



FIG. 6-19 ■ One-stage, one-piece plate/blade form implant with contiguous abutment designed for osteopreservation.

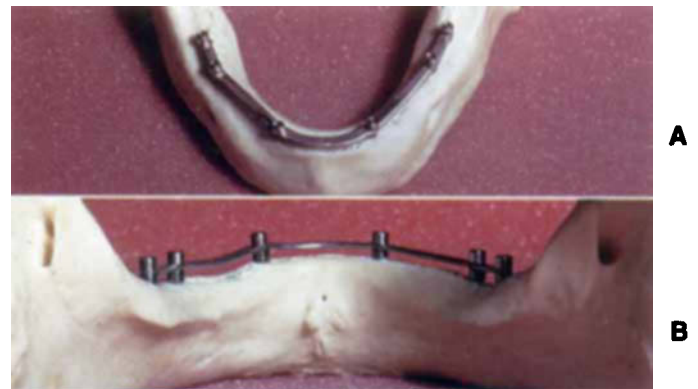


FIG. 6-20 ■ Oral Implant Healing System (OIHS). Occlusal (A) and lingual (B) views of immediate permanent splinting of endosteal implants with titanium bar.

clinically immobile following cementation because of splinting to the natural co-abutment(s), thus promoting successful healing in the osteopreservation mode.³⁹ A controlled diet is maintained, and function is slowly increased over the next several weeks as the bone closest to the implant forms and reorganizes. Thus, the case sequencing to achieve osteopreservation represents a carefully timed coordination between tissue healing and prosthodontic considerations.

An alternative solution to provide immediate and continuing stabilization, in advanced development and early clinical usage, is a titanium immediate postinsertion Oral Implant Healing System⁴⁰ (OIHS) (Fig. 6-20), in which various lengths of nesting titanium connecting bars are secured in position over healing collars with retention collars (Fig. 6-21). These may be used for complete arch splinting as shown in Fig. 6-20, or partial arch splinting (Fig. 6-22) with natural co-abutments. The OIHS immediate splinting bars may serve permanently, can be provided with clip bars for overdentures, or may be removed after healing for more conventional prosthodontic restoration.

The OIHS may also be used with osseointegrated root form and plate/blade form implants for immediate semi-submerged totally stabilized healing. This substantially



FIG. 6-21 ■ Oral Implant Healing System (OIHS). Close-up view of titanium healing collars, nesting connecting bars, and capping collars.

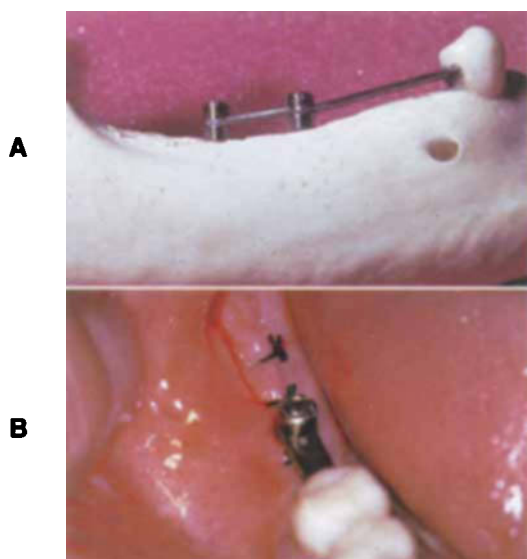


FIG. 6-22 ■ Oral Implant Healing System (OIHS). Buccal (A) and occlusal (B) views of immediate postinsertion splinting to natural teeth.

shortens treatment time and may enable beneficial modifications in root form designs.

Physiology

Peri-Implant Ligament. Although a small percentage of direct bone apposition is observed at the interface of an osteopreserved implant,⁴¹ the majority of tissue at the interface is a peri-implant ligament composed of osteostimulatory collagen fibers. The peri-implant ligament functions in a manner similar to the periodontal ligament⁴² but differs from the periodontal membrane in some anatomic respects.⁴³ The fibro-collagenous peri-implant tissues demonstrate unique orientations and bone interactions that have been shown to be specific to the implant design and condition of functional loading (Fig. 6-23). These fibro-collagenous structures are oriented in the implant-to-bone three-dimensional space following patterns of



FIG. 6-23 ■ Histology of osteopreserved implant after more than 20 years of function in human. Trabeculae of cribriform plate on the left, fibers of the peri-implant ligament in the center, and prior position of implant at lower half of right side. (Courtesy Alfred Feigel, Zurich, Switzerland.)



FIG. 6-24 ■ Histology of transverse section of peri-implant ligament and associated bone trabeculae. Note variations in fiber orientation.

biomechanical strain distribution (Fig. 6-24). The peri-implant zone contains structural orientations that are fundamentally different from those observed in normal *in vivo* ligaments in that they are a physiologic response to the implant-based biomechanical environment. These structures can remain stable for decades of *in vivo* implant-related function.

Collagen fiber bundles in a peri-implant ligament can be significantly longer than those in the periodontal membrane as they pass from insertion in a trabecula of bone of the cribriform plate surrounding the implant, around a

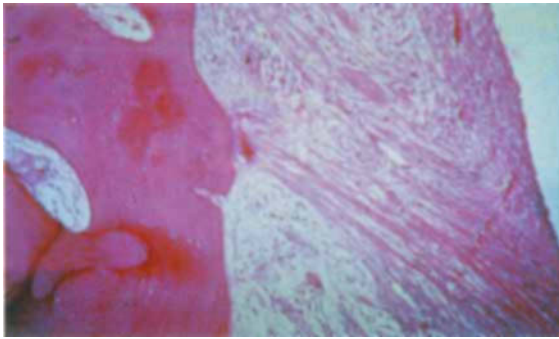


FIG. 6-25 ■ Fibers of a normal peri-implant ligament, following entwinement of an implant strut, insert at right angles to trabeculae of the cribriform plate. Implant at right. (Courtesy Robert James, Loma Linda, Calif.)



FIG. 6-27 ■ Histology of peri-implant ligament forming a sling-like arrangement around base of implant.

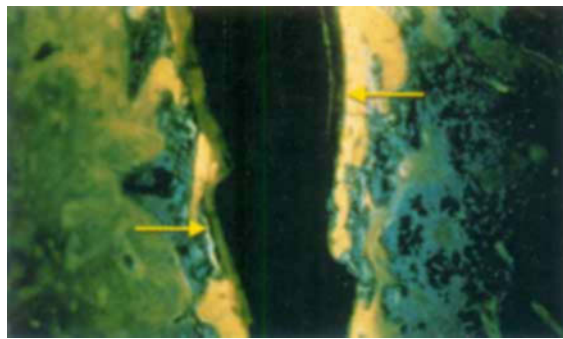


FIG. 6-26 ■ Tetracycline labeling of healing plate/blade form implant. Yellow areas show newest developing bone. Arrows indicate peri-implant ligament.

strut or tangential to the implant surface, and into another trabecula of bone elsewhere in the cribriform plate (Fig. 6-25). The length of the fiber bundles appears to be critical to stability and longevity. Lymphatic crypts are fewer, and vascularity is somewhat less evident than in the periodontal membrane. The thickness of the normal peri-implant ligament space is comparable with that of normal periodontal membranes^{43,44} (Fig. 6-26).

The thickness and density of bone in the cribriform plate around the implant, as shown in Fig. 6-18, often is greater than that observed around teeth.⁴⁵ Hence, the mobility of implants tends to be lower than in the elastic mobility phase of teeth. Peri-implant ligament thickness does vary. The minimal amount of horizontal and intrusion mobility suggests that, at least in some areas around each implant, ligament thickness is minimal.

Histologic examination indicates that fiber orientation, especially at the base of the implant, acts to suspend the implant in a slinglike arrangement⁴⁴ (Fig. 6-27).

Piezoelectric Effect. It is postulated that occlusal forces that pass through the peri-implant ligament fibers stimulate the trabeculae of the implant alveolus into which they are inserted. Bone exhibits a piezoelectric effect, which has

been observed to occur in response to applied force.^{46,47} Studies have indicated that deformation on the aspect of the implant alveolus closest to the implant interface exhibits net compression, creating a net negative charge, while net tension is observed at the outer aspect of deformed trabeculae, creating a net positive charge.⁴⁸ A difference of electric potential is produced between the areas of net compression and tension (Fig. 6-28). The resulting bioelectric environment is postulated to enhance differentiation and proliferation of pluripotent cells into osteoblasts, osteoclasts, and fibroblasts in some relation to the magnitude of the bioelectric current. The action of these cells may promote healing following injury, such as that associated with tissue reflection and osteotomy preparation. Cells also remove debris, lay down a new collagenous network, and calcify it to form bone.

The osteostimulatory piezoelectric effect is postulated to explain in part why the elderly heal more slowly than the young after bone injury. The organic and inorganic content of bone in the elderly is known to be altered. Aged bone is more brittle, harder to deform, and fractures more easily. When stressed, such bone shows a smaller difference in electric potential between areas of tension and compression. This may limit the rate and magnitude of pluripotent cell differentiation and proliferation,⁴⁹ and thereby retard the rate of response and associated healing.

A bone-healing device based on this piezoelectric postulate, called the Gener-Os, is in development (Fig. 6-29). This system imitates and enhances the bioelectric phenomenon by supplying a controlled microcurrent directly to the healing area.⁴⁹ This type of system has been shown to increase cell proliferation and thus increase the rate of healing and bone density. Insertion of electrodes to apply appropriate current to common bone fractures can be difficult; however, this is a less significant problem when dental implants are in position. The negative lead of the device is applied directly to the implant, the positive lead is grounded, and an optimal micropotential and current are delivered to the healing site. The configuration and area of the cathode (the implant electrode) has also been shown to have a direct bearing on the rate and magnitude of cell differentiation and proliferation. In 4 to 6 weeks, these

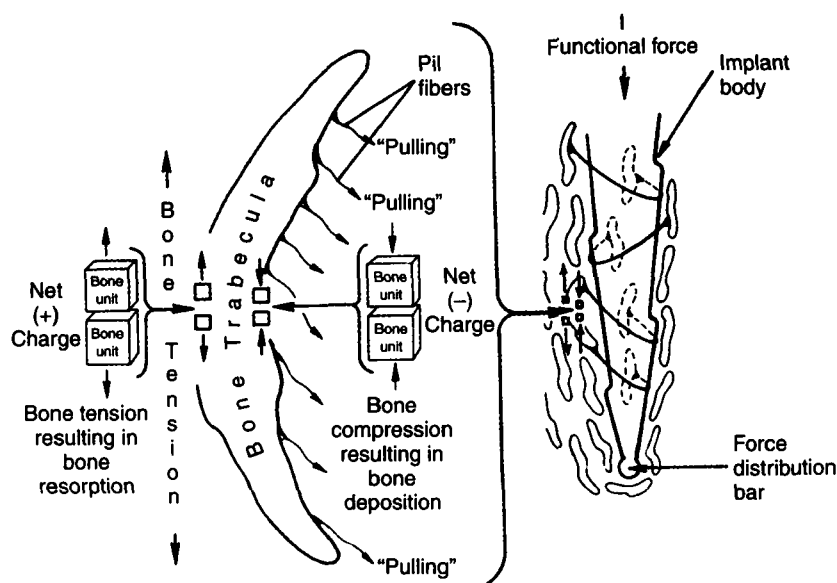


FIG. 6-28 ■ Peri-implant ligament fibers stressed to deform bone trabeculae, postulated to induce osteostimulatory piezoelectric effect.

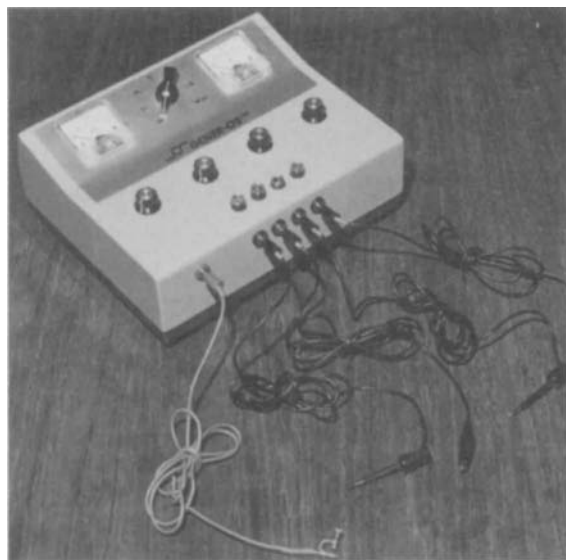


FIG. 6-29 ■ Gener-Os device in development to accelerate bone healing based on piezoelectric principle. (Courtesy Oratronics, Inc.)

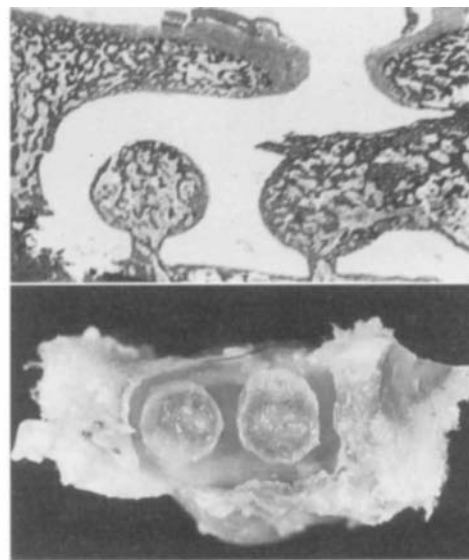


FIG. 6-30 ■ Bioelectric stimulation of bone growth. Histology of rapid formation of dense trabeculation (A) and gross observation of dense cortical bone grown through implant vents (B).

treatments may produce the equivalent of 4 to 6 months of bone healing. This may substantially reduce healing time in the case sequencing treatment protocols for both osteopreservation and osteointegration. Fig. 6-30 shows experimentally induced rapid and dense deposition of cancellous trabeculae within the vents of a plate/blade form implant.

Role of Controlled Fiber Length. Various factors modify the amount of tension applied through the peri-implant ligament, which ultimately is responsible for osteostimulation. The magnitude and direction of force

applied to the implant is critical. Equally important is the length of the collagenous fibers. Because collagen exhibits viscoelasticity, a force applied to a longer fiber is more dissipated than when the same force is applied to a shorter fiber. The design of the implant, including controlled dimensions of struts and vents, shortens fiber length to promote an osteostimulatory effect.

Bulkier implants, such as some root form configurations, cannot stress tangential fibers if they do form, diminishing the osteostimulatory effect as tension is dissipated within excessively long fiber lengths. In the case of

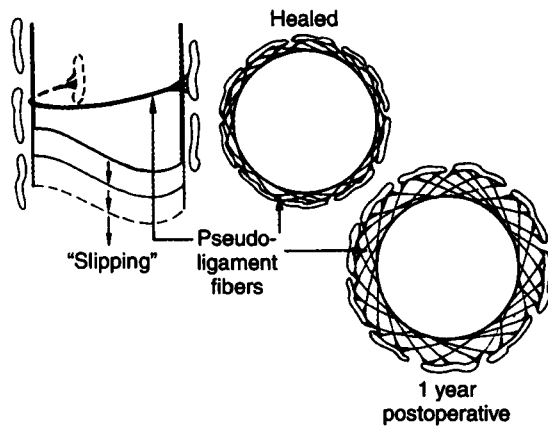


FIG. 6-31 ■ Slipping of smooth stabilizer through collagenous tissue unable to cause an osteostimulatory effect.

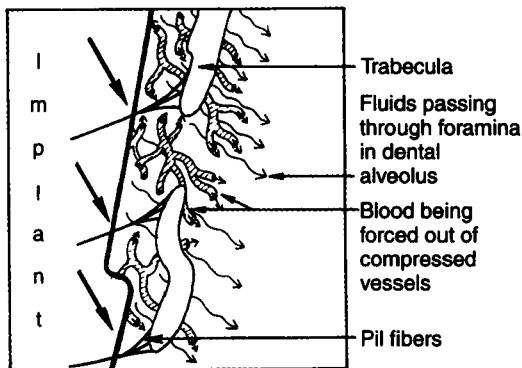


FIG. 6-32 ■ Hydraulic damping effect around an osteopreserved implant.

smaller-diameter smooth bone pins, collagen fibers are short, but they cannot be stressed in function because the pin's smooth interface allows slippage³⁹ (Fig. 6-31). Pseudoligaments or scar tissue can also form, with resulting mobility leading to possible failure.⁵⁰ This type of tissue formation can explain the complications associated with early bulky implants fabricated of vitreous carbon and aluminum oxide, and the smooth tantalum pins used in the 1960s and early 1970s, which could not promote osteostimulation.

Hydraulic Effect. The peri-implant ligament in the implant alveolus is bathed in fluids. In function, as axial forces are applied, compression of groups of ligament fibers forces the incompressible fluids in which they are bathed through foramina in the implant alveolus into the marrow spaces beyond (Fig. 6-32). Blood in vessels coursing among the compressed ligament fibers is also forced out. This action is postulated to create a hydraulic damping effect similar to that observed for natural teeth.⁵¹ As intermittent functional force is released, the fluids are drawn back, and the process can be repeated.

Cushioning Effect. Because the fiber groups of the ligament can be compressed, a **cushioning effect** is created

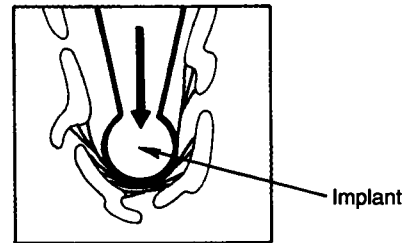


FIG. 6-33 ■ Cushioning damping effect around an osteopreserved implant.

when functional forces press the implant against them and into the alveolus (Fig. 6-33).

Microanatomy. The majority of the interface of osteopreserved implants apposes an osteostimulatory peri-implant ligament at the interface at the light microscopic level,¹ as seen in Figs. 6-23 and 6-25. Most of the remainder of the tissues contacting the interface is made up of bone and marrow.

Shock Absorption/Duty Cycle. The shock absorption qualities of a functional osteogenic peri-implant ligament reduce the peak load during the duty cycle of applied forces as related to magnitude and time.⁴ In addition, because the collagenous fibers of the peri-implant ligament absorb and dissipate force because of their elastic, cushioning, and hydraulic effects, the total amount of force that is transferred to bone surrounding an osteopreserved implant is substantially less than that transferred to bone surrounding an osteointegrated implant.⁵²

Stress Distribution. Three-dimensional finite element computer analysis reveals that the bulk of stress normally is passed to the integrating tissues at the crestal 20% of the implant. In the case of osteopreservation, the peri-implant ligament absorbs the bulk of the functional stress passed through the implant to its integrating tissues. This shields the dense trabeculae of the cribriform plate of the implant alveolus and is thought to account for the excellent bone maintenance associated with osteopreservation in clinical trials.

Mobility. On the day of insertion of a plate/blade form implant, the implant interface and bone forming the walls of the osteotomy are in direct contact. This osteotomy is prepared narrower than the width of the implant, which is why the implant must be tapped gently into its final position. It is initially immobile because of frictional fit. On the day of insertion, there is no clinical mobility.

Injured bone resorbs normally as part of the repair process, and new bone forms concurrently but not as rapidly.⁵³ If left free-standing, some clinical mobility is observed during the time when bone resorption has exceeded new bone formation.⁵⁴ The exact timing of this de-

depends on the anatomic location of bone and area of implant interface. However, when the appropriate case sequencing is followed, the restoration is placed before this mobility is observed. Following cementation, during the time that the implant would normally exhibit mobility during healing, it cannot move because it is splinted to the natural co-abutments. In this sense, the restoration acts as a “cast” to ensure immobilization and hypofunction during healing, and this cast is never removed. Completion of normal healing, remodeling, and long-term maintenance follows.

It is not recommended to permit a one-stage plate/blade form implant to remain unrestored and thus unsupported during the most important stages of its healing, when concurrent bone resorption and bone formation is occurring. Unreinforced provisional long-term acrylic restorations usually are inadequate. Acrylic is too flexible mechanically. The shortened elapsed case treatment time required to ensure immobilization by quickly placing and cementing the final restoration is one of the important benefits of osteopreservation. Therefore, almost always, if one observes early mobility, it is either the result of an inappropriate insertion technique or improper case sequencing.

The cemented restoration will, on Periotest measurements, show the same extent of resilience as natural tooth co-abutments had they not been included in the restoration, normal values being +5 to +9 with no detectable clinical mobility.⁵⁵ Long-term data indicate that the range of normal resilience of an osteopreserved implant decreases over time.^{34,35}

Biomechanical Considerations

The biomechanics of osteopreservation are more complicated than those of osseointegration. In function, the normal micromovement of the osteopreserved implant is equivalent to the normal resilience of a natural tooth with a mobility of zero. The existence of the peri-implant ligament influences the duty cycle of shock absorption, resulting in a lower transmitted load over a greater period and a more favorable biomechanical environment for joining the implant to natural co-abutments under a prosthesis. When occlusal force is applied, osteopreserved implants also exhibit hydraulic shock absorption because the fluids that surround the peri-implant ligament are expressed into surrounding cancellous marrow spaces, as shown in Fig. 6-32. The **hammock ligament**⁴⁴ around osteopreserved implants also exhibits a cushioning shock absorption effect caused by the viscoelasticity of the peri-implant fibers when compressed, as shown in Fig. 6-33.^{4,56} In part because the occlusal force applied to an osteopreserved implant is distributed over a longer period than that applied to an osseointegrated implant, analogous to the duty cycles of normal and ankylosed teeth as shown in Fig. 6-1, less breakage resulting from excessive force and metal fatigue is observed.

Osteopreserved plate/blade forms cannot be used for single-tooth replacements, or for unilateral restorations

without the support of natural co-abutments. This could lead to overloading the implant, progressive widening of the peri-implant fibers, and the absence of an osteostimulating effect.⁵⁰

In unilateral mainstream cases, plate/blade form implants are joined to one or more natural co-abutments. It is specifically this form of treatment that was used in the submitted clinical trials that led to full acceptance from the American Dental Association of a one-stage plate/blade form system.

Three or four osteopreserved plate/blade forms can act as sole support for a complete-arch, 12- or 14-unit fixed restoration. In this case, the biomechanics of “turning the arch” and the benefits of cross-arch splinting obviate the requirement for co-support with natural abutments.

PERIOSTEAL INTEGRATION

Definition

Periosteal integration is the mode of tissue integration around a healed functioning subperiosteal implant in which the prime load-bearing tissue at the interface is a sheath of dense collagenous tissue constituting the outer layer of the periosteum. This sheath diminishes the functional force passed to the underlying cortical surfaces of basal bone.

Applicability

Periosteal integration is the mode of tissue integration of subperiosteal implants. It differs from either mode of tissue integration associated with endosteal implants. The unilateral subperiosteal implant is the mainstream modality of choice for partially edentulous cases in which severe alveolar ridge resorption has left insufficient bone for the insertion of an endosteal implant. An endosteal implant should be used if there is sufficient available bone for insertion. Total subperiosteal implants, which turn the arch, are capable of acting as sole support for an overlying fixed, semi-fixed, or removable restoration (Fig. 6-34). Mainstream unilateral subperiosteal implant cases are used in conjunction with natural co-abutments to support a fixed bridge (Fig. 6-35).

Achieving Periosteal Integration

The key to achieving periosteal integration is proper case sequencing and hypofunctional healing. Limited functional forces should pass through the implant during healing. These factors alter stress-generated bioelectric signals and other biochemical signals that affect the character of the healed environment.

In the case of periosteal integration, the implant is enveloped in the outer layer of the periosteum, which projects fibers through the inner layer that end as Sharpey's-like fibers inserted into bone.⁵⁷⁻⁶⁰ At the time of insertion, the periosteum is placed over the implant, which rests directly on bone. During healing, the periosteum envelops

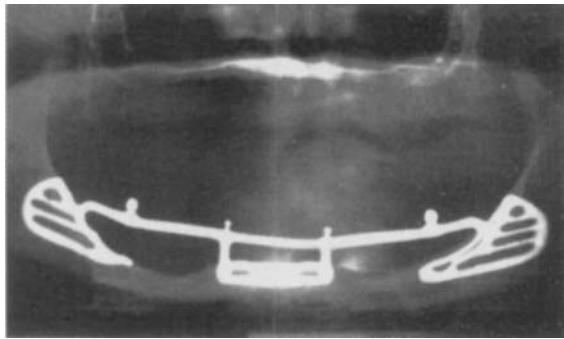


FIG. 6-34 ■ Mandibular total tripodal subperiosteal implant.

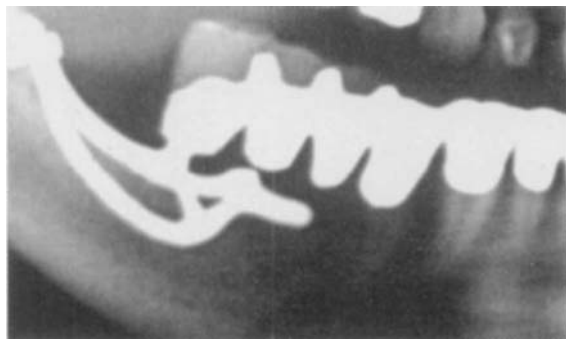


FIG. 6-35 ■ Mandibular unilateral subperiosteal implant with natural co-abutments in support of a fixed prosthesis.

the main bearing and connecting struts. In the absence of implantation, areas of the periosteum that are under tension, such as areas in the presence of muscle tendinous attachments, exhibit a greater concentration of Sharpey's fibers. This is also true of the periosteum enveloping a subperiosteal implant. In this respect, the name subperiosteal implant may be a misnomer, because although it is seated under the periosteum at the time of placement, after healing it is actually an intraperiosteal implant.

In mainstream unilateral cases, most often seen in the posterior arches, the abutment protrudes into the oral cavity on the day of insertion. In nonesthetic areas it is advisable not to fabricate a provisional restoration, to leave the protruding abutment out of occlusion, and to permit the implant to remain in hypofunction during healing.

The final restoration is fabricated and placed as quickly as possible to stabilize the implant against the natural co-abutments, thereby helping to establish thin sheath envelopment around the implant struts.

In the case of periosteal integration, the sequencing of restorative procedures is less critical than for the two types of endosteal tissue integration. This is because collagen is highly reactive, turning over about six times faster than bone.⁶¹ The cortical plates of basal bone that support the enveloped main bearing implant struts are rarely if ever injured to any appreciable extent during the insertion procedure. The healing around a subperiosteal implant is soft-

tissue healing. It is rapid, usually uneventful, and predictable when adequate suturing to prevent soft-tissue dehiscence is performed at implant insertion. Full function can be initiated within 3 to 5 weeks.

Mainstream unilateral cases are not proved to be able to support free-standing restorations. These implant abutments are treated essentially the same as osteopreserved abutments, in that they are used in conjunction with natural co-abutments under a restoration to support a fixed bridge. Periosteal integration, osteopreservation, and the resilience of natural teeth are biomechanically similar and compatible in clinical practice, although not identical.

Total subperiosteal implants, which are not considered mainstream because of their complexity, often are temporized. With careful patient dietary instruction, they too should remain in hypofunction during the short healing period.

Physiology

The occlusal forces applied to a periosteally integrated subperiosteal implant are essentially passed through main bearing struts enveloped by collagenous fibers of the outer layer of the periosteum. These forces ultimately are absorbed by the external cortical plates of the underlying basal bone. The periosteum consists of two layers. The inner layer is essentially composed of pluripotential cells that, in areas of injury, differentiate and proliferate into the cells required for healing. The outer layer is composed of dense bundles of collagenous connective tissue, fibers of which pass through the inner layer of periosteum and insert into bone as Sharpey's fibers.

Because the subperiosteal implant is enveloped in a sheath of dense fibrous connective tissue of the outer layer of the periosteum, it is essentially tied into the periosteum, and through it to the underlying bone. Note again that the concentration of Sharpey's fibers is substantially higher in areas of the periosteum associated with subperiosteal implants.^{43,62} This promotes firm, long-term retention of the implant.

Hydraulic Effect. The hydraulic effect is not as pronounced in periosteal integration as it is in osteopreservation, but it is a damping factor. The enveloping tissues are bathed in fluid and have vascular elements that provide a hydraulic damping effect in response to functional loading.

Microanatomy. The periosteal sheath that envelops the implant and is attached to the underlying bone has many characteristics of a ligament. Although there are fewer microscopy studies available related to subperiosteal implants than for osteointegrated and osteopreserved implants, they all confirm the presence of the enveloping sheath.⁶³

Because periosteal integration has been poorly understood and inadequately described in the literature, a complete description is presented here. In a landmark animal study, following 24 months of function after insertion (Fig. 6-36), a subperiosteal implant and its investing tissues were prepared for histologic evaluation.^{59,60} A hematoxylin and



FIG. 6-36 ■ Unilateral subperiosteal implant at time of insertion. (From Russell TE, Kapur SP: *J Oral Implantol* 8:3, 1977.)

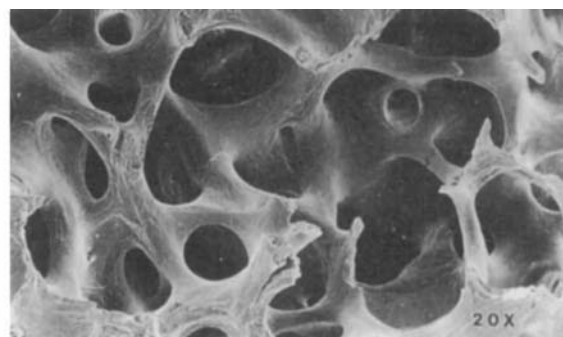


FIG. 6-39 ■ Trabecular pattern of control specimen. (From Russell TE, Kapur SP: *J Oral Implantol* 8:3, 1977.)



FIG. 6-37 ■ Hematoxylin and eosin-stained section. *I*, implant space; *PIS*, peri-implant sheath; *TB*, trabecular bone. (From Russell TE, Kapur SP: *J Oral Implantol* 8:3, 1977.)

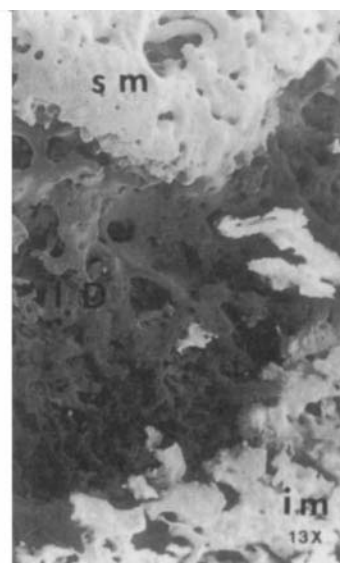


FIG. 6-40 ■ Anorganic implant support. *sm*, superior margin; *im*, inferior margin; *ID*: implant depression. (From Russell TE, Kapur SP: *J Oral Implantol* 8:3, 1977.)

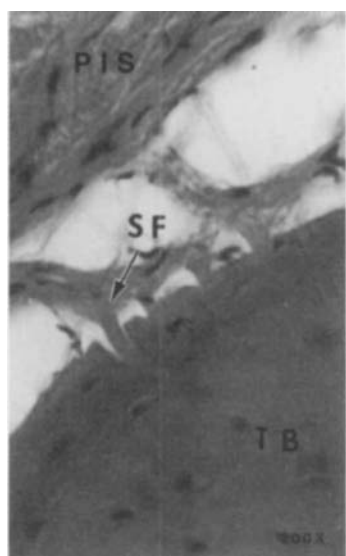


FIG. 6-38 ■ Sharpey fiber bundle (*SF*) passing from the peri-implant sheath (*PIS*) into trabecular bone (*TB*). (From Russell TE, Kapur SP: *J Oral Implantol* 8:3, 1977.)

eosin-stained section at $\times 40$ magnification revealed the relationships among the implant, peri-implant sheath, and adjacent bone (Fig. 6-37). At $\times 200$ magnification (Fig. 6-38), Sharpey's fibers were observed inserting directly into bone. As a control, scanning electron microscopy of trabecular bone in the area at $\times 20$ magnification revealed the equivalent of the anatomy that was thought to have existed preoperatively (Fig. 6-39). At $\times 13$ magnification, following implant removal, the depression in which it had been seated and character of bone at the superior and inferior margins revealed the unique trabecular anatomy in the presence of Sharpey's fiber insertion, confirming the occurrence of dense aggregates of these fibers wherever periosteum is subjected to various forces, that is, at muscle attachments and areas of periosteal integration around a subperiosteal implant (Fig. 6-40). At $\times 400$ magnification, areas of Sharpey's fiber insertions were noted alongside deeper trabecular portions not stimulated by direct functional force applied to the periosteum (Fig. 6-41). At $\times 2800$ magnification, anatomic variations of Sharpey's fiber insertions were ob-



FIG. 6-41 ■ Trabecula with Sharpey fiber insertion area (SFI). (From Russell TE, Kapur SP: J Oral Implantol 8:3, 1977.)



FIG. 6-42 ■ Partially mineralized Sharpey fiber insertion (SFI) holes. (From Russell TE, Kapur SP: J Oral Implantol 8:3, 1977.)

served. Sharpey's fiber insertions (Fig. 6-42) were observed as partially mineralized holes, with axial mineralization and elevated peripheries. Another variation observed at $\times 2800$ magnification revealed fully mineralized Sharpey's fiber insertions, probably in areas of greater function (Fig. 6-43). A larger area of inorganic periosteal bone at $\times 170$ magnification demonstrated various forms of Sharpey's fiber insertions and surrounding anatomy (Fig. 6-44).

Shock Absorption/Duty Cycle. The shock absorption qualities of functional periosteal integration dissipate the peak load during the duty cycle of applied forces over time. This is essentially a damping effect that results from cushioning.

Stress Distribution/Role of Basal Bone. Data related to subperiosteal implants are insufficient from three-dimensional finite element computer analysis. In total subperiosteal cases, it is important that design considerations take into account that the mandible flexes in function. A complete arch frame that is excessively rigid can cause shear at the interface. In the case of mainstream unilateral subperiosteal implants, this is not a concern.

The main bearing struts rest over basal bone, which absorbs and transmits the forces of function. Main bearing struts are positioned to absorb applied forces from all directions. Axial, right and left lateral, and anterior force components are all resisted by appropriately placed main bearing struts, as described in Chapter 14.

Mobility. In common with all dental implants, mainstream unilateral subperiosteal implants require relative immobility, particularly during the early phases of soft-tissue healing. At insertion, the implant rests directly on bone. To achieve primary retention and promote early immobility, the implant is designed such that some of its struts seat into undercut areas. In many cases, when proper design is facilitated by favorable bony anatomy of the host site, the initial immobility achieved by incorporating de-

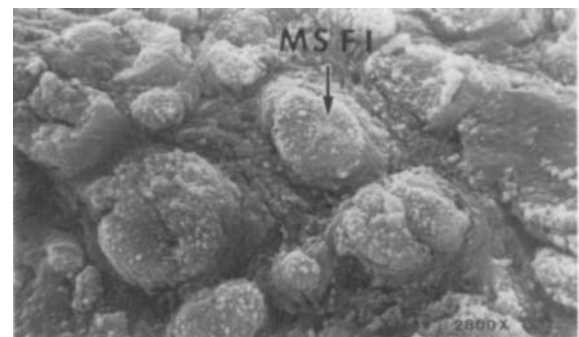


FIG. 6-43 ■ Mineralized Sharpey fiber insertions (MSFIs). (From Russell TE, Kapur SP: J Oral Implantol 8:3, 1977.)

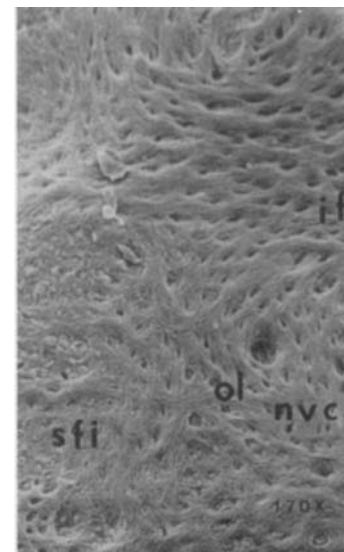


FIG. 6-44 ■ Anorganic periosteal bone. Various forms of Sharpey fiber insertions (sfi), osteocyte lacuna (ol), intrinsic fiber matrix (if), and neurovascular canals (nvc). (From Russell TE, Kapur SP: J Oral Implantol 8:3, 1977.)

sign elements with slight undercut areas is all that is required. Often, however, added initial retention must be gained through the use of one or two **retaining screws** passed through strategically located holes placed within main bearing struts. These screws, firmly embedded in cortical bone, serve only for provisional retention and early immobilization. Most often they do not need to be removed. Secure suturing closure can also enhance primary stability during the first days postinsertion.

Subperiosteal implants can exhibit lack of mobility long-term. Many patients have had immobile total subperiosteal implants in service well in excess of 20 years.⁶⁴ In some cases, slight mobility is observed and is considered to be acceptable. If observed, treatment of excessive mobility should include occlusal equilibration, improved home care, and increased frequency of professional maintenance.

Biomechanical Considerations

The dense fibrous sheath that envelops the subperiosteal implant differs from the periodontal or peri-implant ligament composed of osteostimulatory fibers that envelops the struts of osteopreserved endosteal implants. Nonetheless, these structures are biomechanically similar, since each provides resilience similar to that of natural teeth. Because the size of the subperiosteal implant is directly proportional to the number of missing teeth, and therefore to the size of the partially or totally edentulous ridge, the size of the implant is almost always sufficient to support the loads to which it is subjected in function. The enveloping tissues also provide cushioning.

Because subperiosteal implants are enveloped in soft tissue, they generally are not splinted to osteointegrated implants but can serve as co-abutments under a restoration with osteopreserved plate/blade form implants. Unilateral mainstream subperiosteal implants should not support a free-standing prosthesis. They should be joined to natural co-abutments, using the same techniques and considerations advocated for osteopreserved plate/blade form implants.

BENEFITS OF USING ALL MODES OF TISSUE INTEGRATION

On the scientific level, osteointegration, osteopreservation, and periosteal integration all are valid. Properly used, each of the three modes of tissue integration succeeds, and is safe and effective long-term. The differences lie in clinical application. Consider that in most cases, the available bone presented by the patient dictates the use of a specific implant modality, and that most implant modalities have only one tissue integration option. In such cases, determining which type of tissue integration is preferable simply is not relevant. What is relevant is that the ability to use all three modes of tissue integration increases scope of treatment and allows the practitioner to serve more patients.

In cases in which more than one modality may be applicable, one may select the mode of tissue integration. Chapter 16 provides guidance for making this decision case by case, taking into account one's level of comfort or familiarity with the modality options, the most appropriate type of restoration for the case at hand, and other factors.

It is true that, just as knowing how to use several implant modalities improves one's capacity to serve a broader range of patients, knowing the principles, clinical implications, and indications for osteointegration, osteopreservation, and periosteal integration makes one a better, more comprehensive practitioner of implant dentistry. High levels of knowledge and comfort with each of the three modes of tissue integration allows one to serve a broader spectrum of patients, and to offer more comprehensive treatment to any given implant dentistry candidate. This materially enhances one's level of treatment.

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7 Scientific and Clinical Acceptability of an Implant Modality

A proliferation of new products is enabling dental implant practitioners to offer more patient services. Ultimately, it is the practitioner who is responsible to the patient when treatment is rendered using any product, whether new or time-tested. Therefore, it is important that one evaluate products using valid criteria to assess whether they are scientifically and clinically sound.¹

There is a tendency to believe that what is new is better, but this is not necessarily so. In fact, establishing that a product innovation such as a new implant system or interface is advantageous takes time. Only long-term usage can establish that an innovation is safe and effective long-term.

Acceptance must first be based on scientific criteria that validate the long-term safety and efficacy of a system.² Fulfilling this condition is referred to herein as being *scientifically acceptable*. The innovation must be demonstrated to perform well for its intended purpose of providing new abutment support for restorative dentistry.

Although satisfying scientific criteria is an essential step toward gaining professional acceptability, it is not the only step. The system must also satisfy clinical criteria to demonstrate that it is suitable for general use by the profession, that it may be adopted for use on a wide scale. Fulfilling this condition is referred to herein as being *clinically acceptable*.

Scientific and clinical criteria are both very important. An example helps to illustrate this point. Endodontic therapy is a treatment that is both scientifically acceptable, in that it is safe and effective, and clinically acceptable, in that it can easily be incorporated as a service offered by many practitioners. Of course, endodontic therapy would not be a useful treatment if it were not scientifically sound. At the same time, it also would not be particularly useful if it were not clinically sound. What if, because of technique sensitivity, only a very small percentage of dental practitioners could provide endodontic therapy? What if the therapy were so costly that almost no patients could afford it?

What if every time endodontic therapy were performed, office procedure were disrupted so profoundly that one's practice was compromised? If such were the case, endodontic therapy would not satisfy the clinical criteria for general use, despite meeting the scientific criteria that demonstrate safety and efficacy.

When a discipline is both scientifically and clinically acceptable, such as prosthodontics, periodontics, endodontics, and oral surgery, it may become an integral part of conventional dental treatment. The mainstream applications of the professionally accepted modalities presented in this book, which are scientifically and clinically acceptable, suggest that implant dentistry is a discipline that can now be integrated into conventional dental treatment.

Not all treatment that uses a scientifically and clinically acceptable implant system is considered mainstream. Chapter 18 presents such non-mainstream cases. Intermediate- and advanced-level treatment is appropriate for patients who have serious complications or challenging preoperative presentations. However, the focus of this book is on the mainstream applications of implant modalities and systems that are both scientifically and clinically acceptable. Mainstream treatment is the most predictable and the most widely applicable to help the majority of patients in need.

CRITERIA FOR SCIENTIFIC ACCEPTABILITY OF AN IMPLANT MODALITY

The mainstream applications of five implant modalities that satisfy the criteria for scientific and clinical acceptability are demonstrated in the step-by-step teaching case chapters. The most important precondition for designating an implant modality as acceptable is that it be supported by adequate valid scientific evidence. There can be no doubt that the modality is safe and effective for its intended purpose. The data that support the scientific acceptability of the abutment-providing

BOX 7-1 ■ CRITERIA FOR SCIENTIFIC ACCEPTABILITY OF AN IMPLANT MODALITY OR SYSTEM

Human clinical trials
 Prospective trials
 Independent
 Controlled
 Randomized
 Longitudinal
 Serial studies
 Retrospective studies
 Case reports
 Governmental and professional association acceptance/approval
 American Dental Association
 Food and Drug Administration
 Dental implant-related academies
 Abundance of favorable clinical data

implant modalities presented in this book are detailed in Chapter 8.

Scientific credibility can be established in several ways, such as the existence of valid scientific studies and clinical trials, acceptance or approval by a government agency or professional society, and/or the availability of an abundance of clinical data based on widespread usage for a substantial period (Box 7-1). Each of these avenues of scientific validation is discussed in detail below.

All five dental implant modalities covered in this book are supported by valid evidence of safety and efficacy. Each is supported by some, but not necessarily all, of the avenues by which scientific acceptability can be established. For example, because each subperiosteal implant is a custom-made device, conducting a classic prospective clinical trial on the subperiosteal implant modality is complicated by the existence of variables that cannot be eliminated. However, the difficulty of conducting a prospective or retrospective clinical trial on subperiosteal implants does not mean that there is insufficient evidence of their scientific acceptability. On the contrary, numerous valuable studies have been conducted regarding subperiosteal implants,³ and importantly, this modality has been in use for more than four decades.⁴ Thousands of cases treated with subperiosteal implants have been reported, and reports of a widespread incidence of unexplained complications have been absent. In addition, the Council on Education of the American Dental Association and the board of trustees of the American Academy of Implant Dentistry have expressed favorable opinions about the safety and efficacy of appropriately diagnosed subperiosteal implant treatment by experienced practitioners for fully informed patients.⁵ Similarly, each of the other modalities is supported by one or more, but not necessarily all, of the avenues that establish scientific acceptability.

Human Clinical Trials

The classic criterion for establishing the scientific acceptability of any treatment technique or device is the existence of a controlled and randomized longitudinal human clinical trial conducted by independent investigators following prospective study-based protocols.⁶ Often, preclinical animal studies are conducted to establish the advisability of conducting the human clinical study, as well as to provide information that may facilitate the study.

There are several types of human clinical trials; each yields differing types of data. In this section, four types of investigations that often are conducted in implant dentistry are discussed: **prospective studies**, **serial studies**, **retrospective studies**, and **case reports**.

Prospective Clinical Trials. In a prospective trial, an objective is conceived to test a hypothesis. A course of action is then blueprinted to meet the established objective. In creating the study protocol, the subjective and objective criteria for success or failure, as well as methods of measurement and statistical validation, are determined. All such parameters are established before conducting the trial. This ensures validity.

There are several types of prospective clinical trials. Some are closer to ideal than others. The ideal trial includes independence, randomization, controls, longitudinal treatment of data, and objective measurements for statistical validity.⁷ Prospective trials that do not meet all of these criteria may still have value, but the data yielded by a trial that meets all of these criteria are considered to be the most valuable. Although few in number, studies have been conducted in implant dentistry that satisfy these criteria for an ideal prospective human clinical trial.^{8,9} Descriptions of these criteria follow. Understanding these criteria helps one to evaluate the relative validity of the trials presented in Chapter 8.

Independent. The term *independence* means that the investigator is impartial with regard to the results of the study. The investigator does not stand to benefit, whether the anticipated study outcome is achieved or not. Thus, studies conducted by developers of devices, or manufacturers of products used in the study protocol, no matter how thorough the methodology, are not independent. A clinical trial that is not independent may be of value but should be carefully analyzed to ensure that bias has not influenced the results.

Controlled. A controlled study uses a simultaneous and/or historical control group for direct comparison to the experimental group. All studies include an experimental group, in which the experiment is the use and evaluation of a new procedure or device. Use of a control group is important. The control group does not undergo the same procedure as the experimental group. This provides the investigator with data to which the experimental data can be compared. Studies that do not use a control group have no point of reference. Their results data can be informative but cannot be considered as informative as those derived from a controlled trial.

Randomized. The term *randomization* means that subjects within the trial are assigned to the control or experimental groups randomly. This is an important element for many study types. If, for example, a trial sets out to compare experimental group A with control group B, and the most ideal subjects are assigned to experimental group A and the least ideal to control group B, the trial is biased. Most prospective human trials establish parameters for the fitness of subjects to participate in the trial—for example, freedom from certain types of pathology, absence of habits that would interfere with the experimental procedure, and lack of known allergic reaction. In the case of dental implant trials, the parameters for subject fitness can include considerations such as partial edentulism in a certain area, a minimum amount of available bone, or other conditions. A population that satisfies fitness requirements may still show substantial variation of fitness for the experimental procedure. A healthy 25-year-old may be deemed to have a higher chance of achieving an end-point outcome that meets **success criteria** than a comparatively unhealthy 80-year-old, even when both satisfy the parameters of general patient fitness for inclusion in the trial. All of the subjects fulfilling the study fitness requirements must be randomly assigned to the experimental or control groups without regard to their capacity to satisfy the success criteria of the experimental procedure.

Longitudinal. The term *longitudinal* means that every subject in every experimental and control group is accounted for and measured at the same time intervals. No person or group is excluded at any measurement interval except under preestablished conditions, and the same measurements are conducted for all aspects of the study. This ensures that no results are omitted under conditions that may develop during the investigation.

Serial Studies. Serial studies provide much valuable data. The form and purpose of such studies differ from those of prospective trials. In a prospective trial, an objective is conceived, and the trial is conducted to meet the objective. In a serial study, an investigator or group of investigators performs a procedure serially on numerous subjects and reports the results. Serial studies may or may not be independent, generally are not controlled, and for the most part are not randomized insofar as all of the subjects are hand-picked for fitness to undergo the procedure.

In a serial study, outcomes tend to be specific to the investigators. If, for example, a serial study is conducted in which 10 investigators each choose 5 ideal subjects on whom to perform a dental implant procedure, each of these investigators must be relied on to report their successes and failures, all other considerations aside. An obvious question is, can 10 investigations, each in different locations and often unknown to one another, interpret “ideal” in the same way? One must also account for differences in skill level among the investigators and potential differences in treatment procedures.

Despite uncertainties associated with this type of investigation, some of the most important and influential clinical

BOX 7-2 ■ PRINCIPLES ESTABLISHED BY NIH/FDA CONSENSUS DEVELOPMENT CONFERENCE ON DENTAL IMPLANTS FOR PROPERLY CONDUCTING SERIAL STUDIES

- Prospective statement of study aims. Clear definitions of success and failure for all measures
- A description of the study population and criteria for patient selection
- Standardization to the extent possible of treatment outcome measures, with presentation of data on reliability. Use of independent examiners is advisable
- Adequate sample size adjusted for the expected attrition over the life of the study
- Concise reporting of the reasons for attrition
- Reporting of all failures from the time of the insertion of the implant
- Documentation and follow-up of all failures
- Use of standardized reporting measures, including life tables
- Limiting extrapolation of results to population similar to that of the study under similar experimental conditions

ical trials conducted in implant dentistry have been serial studies.^{10,11} In evaluating the validity of serial studies, it is important to consider carefully the methods, procedure for selecting the subjects, and the manner and objectivity of measuring and reporting the results.

In 1988, the National Institutes of Health (NIH), in conjunction with the U.S. Food and Drug Administration (FDA) and the dental profession, conducted a Consensus Development Conference on Dental Implants. In their conference statement, the NIH, FDA, and dental practitioners established criteria establishing how serial studies should be conducted.¹² This statement asserted that “Although the ideal research design for documenting the effectiveness of a new treatment technique should be a randomized, controlled clinical trial, case series studies are capable of providing limited evidence when proper methods are used.”¹² The principles embodied in the conference statement to increase the validity of data derived from serial studies are shown in Box 7-2. Case studies conducted in implant dentistry adhere to these principles to varying extents and should be analyzed within this context.

Retrospective Studies. Retrospective studies are recognized to have value but, again, demonstrate a wide range of subjectivity and validity, especially when compared with the rigor with which prospective studies are conducted. In a typical retrospective study, a highly experienced practitioner or an institution such as a hospital reports the results of a given treatment over the course of years. To some extent, such reports may be inherently biased, insofar as most practitioners and institutions choose to publish outcomes that highlight success rather than failure. It is also important to consider evolving methodology and skill level

when evaluating the validity of any retrospective study. Despite these shortcomings, many valuable retrospective studies have been performed in implant dentistry,¹³⁻¹⁵ and whether or not they are reported ideally, each such study incrementally adds to the total amount of available clinical data related to the safety, efficacy, and effectiveness of a given procedure.

Case Reports. Case reports tend to have more specialized intent. Most are not intended to provide data regarding whether an implant modality or system is safe and effective. Instead, they often report unanticipated occurrences, such as an unexpected complication, or the successful treatment of a case far from mainstream, often using advanced methods. Case reports can be very informative to practitioners who deal with implant treatment every day, insofar as such reports can orient practitioners regarding what can be done in advanced-level cases, or what they should or should not do to avoid unexpected or unusual complications.

Governmental and Professional Acceptance/Approval

The typical dental implant practitioner associates validity of an implant modality with official acceptance or formal approval by an independent government body or agency, a professional organization of importance, or both.

Acceptance or approval by a government-based agency ensures that a protocol-based trial has been performed, that the results have been scrutinized and deemed valid by the agency in question, and therefore that the implant modality or system is considered safe and effective for its intended purpose.¹⁶ Acceptance or endorsement by an implant dentistry academy may or may not be based on clinical trials but does indicate the existence of clinical data based on reported usage by the members of that professional organization.

American Dental Association Dental Implant Acceptance Program. The procedure by which American Dental Association (ADA) acceptance is granted for an implant system is stringent. The ADA recommends the submission of two independent prospective clinical studies with a sample size of at least 50 patients, each evaluated periodically over a period of 5 years, for full acceptance. In studies of this type, the following clinical evaluation criteria must be considered: mobility; radiolucency; bone loss; gingival health; pocket depth; effect on adjacent teeth; function; esthetics; presence of infection; discomfort or paresthesia; intrusion into the mandibular canal, maxillary sinus, or nasal cavity; the patients' psychological responses; and lack of serious morbidity in instances of implant failure.¹⁷

Furthermore, characteristics of the implant design and material, as well as procedures for fabrication, packaging, and sterilization, must be verified as safe and effective. Data related to implant biomaterial compatibility, mechanical properties, surface characteristics, and quality control and assurance are required.

The ADA revised its requirements for acceptance in 1995.¹⁸ According to current guidelines, a clinical trial of an implant system must include a valid sample of implants placed in less favorable locations, for example, in posterior quadrant edentulous ridges, where applied occlusal force is greater than that applied to implants placed anteriorly.

Objectively evaluated survival rates are expected to exceed 85% at 5 years, and the percentage of implant failures occurring during the last 2 years of the study should not be significantly different from those reported throughout earlier stages of the study.

At this time, few implant systems have achieved full acceptance by the ADA, and more have been granted provisional acceptance,¹⁹ meaning that they have demonstrated sufficiently favorable safety and efficacy over a 3-year period to suggest that full acceptance will be granted after the 5-year data have been submitted.

U.S. Food and Drug Administration. The Initial Medical Device Oriented Legislation in 1976 authorized the FDA to regulate surgical implant devices involved in interstate commerce. It specified that implant systems on the market when the law was enacted could be considered "grandfathered" and remain at market to provide a period for manufacturers to submit evidence of safety and efficacy. This law on device regulation provided that new implant systems could be brought to market if the manufacturer could demonstrate "substantial equivalence" of the predicate device to one that was marketed preenactment, or one that was approved for use.

In 1997, the FDA passed the Food and Drug Administration Modernization Act (FDA-MA) to streamline the process of approval of medical and dental devices, and to move toward creating performance standards for newer devices.

Implant Dentistry Academy Acceptance. Implant dentistry academies provide information regarding the acceptance of implant modalities. For example, in 1997, the American Academy of Implant Dentistry (AAID) released a position paper entitled "Accepted Modalities in Implant Dentistry."⁵ This paper is valuable as a clear and concise statement that validates the use of modalities with proven long-term safety and efficacy. In addition, this paper supports and advocates the multimodality approach to implant dentistry to maximize the practitioner's scope of treatment and ability to serve a larger number and wider range of patients. Excerpts from this position paper, limited to those that are relevant to the modalities covered in this book, are reprinted with permission in Box 7-3.

The American Society of Periodontists has published consensus statements related to the parameters of osseointegrated root form treatment.²⁰ The American Board of Oral Implantology/Implant Dentistry (ABOI/ID), in its written examination, requires familiarity with a variety of endosteal and subperiosteal implant modalities, and in its clinical case submission and defense process, requires that at least two modalities be represented. In December 1997,

BOX 7-3 ■ EXCERPTS FROM AAID POSITION PAPER ON MULTIPLE MODALITIES IN IMPLANT DENTISTRY**POSITION**

The AAID finds the modalities listed herein to be safe and effective when properly utilized. Practitioners should familiarize themselves with each of these modalities as valid treatment options in order to afford appropriate and comprehensive care for the greatest number of patients.

COMMON CONSIDERATIONS

The benefits of a multimodality approach to implant dentistry are undeniable. It is the particular applications and advantages of each system that profoundly increase the scope of treatment, enabling practitioners to bring the benefits of implant dentistry to the greatest number of patients.

For a significant portion of implant candidates, one or more modalities may be indicated due to considerations such as insufficient or overabundant available bone. In cases where more than one modality may be utilized, additional considerations may require attention. For example, patient considerations such as time, physical and emotional trauma of treatment, age, general health, cost, esthetics, and expectations may lead to the use of different implant modalities in patients with equivalent clinical presentations.

Successful implant therapy can only be attained through a cooperative effort between patient and clinician. The patient should be provided sufficient information regarding the benefits and risks attendant with each proposed treatment option.

Clinicians should inform patients of their responsibilities, which must be fulfilled in order to realize treatment success.

ACCEPTED MODALITIES—ENDOSSEOUS

Root form. Root form implants are utilized for the support of single tooth, partial, or complete arch prostheses in the maxilla or mandible. In the maxillofacial region, root form implants can support a variety of extraoral prostheses.

Plate/blade form. The plate/blade form can support partial and complete arch prostheses in the maxilla or mandible.

Endodontic stabilizers. Endodontic stabilizers extend through the root apex of a tooth into bone to enhance the crown-root ratio.

ACCEPTED MODALITIES—UNILATERAL, CIRCUMFERENTIAL, AND TOTAL SUBPERIOSTEAL

A subperiosteal implant is a custom-cast metal framework that is placed over the bone to provide support for a dental prosthesis.

ACCEPTED MODALITIES—INTRAMUCOSAL INSERTS

Intramucosal inserts are mushroom-shaped projections attached to the tissue surface of a maxillary prosthesis. They insert into tissue receptor sites and are utilized with removable prostheses.

a group of experts (nine ABOI/ID diplomates and one professor of prosthodontics) convened a Consensus Conference on Subperiosteal Implants under the leadership of the then-president of the AAID.²¹ Others would do well to emulate these positive examples. If in the future other academies publish or otherwise establish positions on implant dentistry, they will be welcome contributions to the body of supporting literature and will help to illuminate the future path of implant dentistry.

Abundance of Favorable Clinical Data

For some professionally accepted modalities, such as subperiosteal implants and intramucosal inserts, few, if any, prospective clinical trials have been conducted primarily because the number of variables is too great. For these modalities, one avenue for validation of safety and efficacy is an abundance of long-term clinical data that have been accumulated because the modality has been used successfully for many years.²² Modalities that have proven validity via human trials also tend to be supported by abundant long-term clinical usage.

Preponderance of Cases Over Meaningful Time Period. Root forms, plate/blade forms, subperiosteal implants, intramucosal inserts, and endodontic stabilizers are supported by data extending over more than 20 years^{4,23-26} in innumerable cases. These numbers imply general usage

by thousands of practitioners at various levels of skill over a substantial period, indicating widespread clinical applicability. This is what happens when any health-related breakthrough becomes incorporated into general practice. Long-term, widespread usage establishes that the incidence of untoward complications has been low and that the modality is clinically acceptable for use by a substantial number of practitioners. Any latent complications that could be associated with an implant modality would have become apparent over the course of several decades. In the absence of a significant number of clinical reports citing failures of specific etiology observed at similar time intervals, practitioners can be reassured that dangers do not exist on a wide scale. Use of the modality in such a large number of cases also shows that there is an established need for the benefits that the modality provides.

Long-Term Bone Maintenance Superior to That of Unimplanted Ridges. The use of a modality over decades in multitudinous cases addresses the “abundant” portion of “abundance of favorable clinical data.” Maintenance of the implanted alveolar ridge under conditions that are clinically superior to those of unimplanted ridges addresses the “favorable” consideration. Early in the evaluation of implant modalities by the profession, the question was raised, “How much bone resorption is acceptable in an implanted alveolar ridge?” It was proposed that if it could be shown that the alveolar ridge showed less resorp-

tion over time after device implantation than in the average unimplanted ridge, then endosteal implant dentistry could be considered preventive.²⁷ Compared with the known rates of resorption of unimplanted ridges, each of the abutment-providing endosteal modalities presented in this book can be considered preventive, in that each significantly reduces the rate of resorption of the alveolar ridge. These data are presented in Chapter 8.

Preservation of Teeth. The preservation of teeth is another consideration that determines whether the long-term usage of an implant modality yields favorable clinical results. To evaluate this consideration, the use of endosteal implants to help support fixed bridges was compared with the use of removable partial dentures.⁷ Removable partial dentures have been associated with the serial loss of teeth that are clasped for attachment. It has been shown in prospective and retrospective clinical trials that the use of plate/blade form implants, which use adjacent natural dentition as co-abutment support for a fixed bridge, results in a higher percentage of preservation of remaining teeth than that associated with removable partial dentures. In one of the seminal studies reported on plate/blade form implants in Chapter 8, not one natural co-abutment supporting an implant-supported fixed bridge was lost during the study, whereas a significantly higher percentage of teeth used for partial denture retention in the control group were lost.⁸ Root form implants, which as a rule do not use natural co-abutments, also influence the survival of the remaining natural teeth positively because their use precludes the need for clasping the adjacent dentition for removable denture retention.

CRITERIA FOR CLINICAL ACCEPTABILITY OF AN IMPLANT SYSTEM

The proper position of implant dentistry within the general practice of dentistry is being established. Implant dentistry is not so complex that it must only be performed by a select percentage of practitioners for a small portion of candidate patients. The ability to add new abutment support for restorative dentistry for partially or totally edentulous patients needs to be practiced by the profession on a wide scale. The estimated number of implant dentistry candidates in the United States alone—120 to 140 million—cannot be cared for properly unless implant treatment is incorporated into the general practice of dentistry. It therefore is incumbent on the profession to incorporate the mainstream applications of implant dentistry into general practice, in the same way that it has incorporated endodontics, periodontics, prosthodontics, and oral surgery. General practitioners can and should treat mainstream cases and refer to specialists those cases they cannot or wish not to treat.

This aspiration can be achieved because the implant modalities covered in this book satisfy the criteria for clinical acceptability that follow (Box 7-4). In addition to being scientifically proven to be safe, the modalities facilitate proper diagnosis, are technique-permissive, and can be used cost efficiently.

BOX 7-4 ■ CRITERIA FOR CLINICAL ACCEPTABILITY

Ease of training
Acceptable number of patient visits and elapsed treatment time
Ease of incorporation into conventional office routine
Acceptable start-up, implant, and component costs
Compatibility with conventional prosthodontics
Use of existing bone and attached gingiva
Ability to perform single-tooth or freestanding replacement
Adequacy of in-office radiography
Ease of sterilization
Ability to routinely achieve good esthetics
Interchangeability of components
Ease of maintenance

Following is an analysis of the clinical criteria that determine that an implant modality can be incorporated into routine general practice. No modality meets all of these criteria. Each has associated advantages and disadvantages. However, each meets enough of the clinical criteria to be regarded as clinically acceptable. Evaluating each modality and each implant system against these criteria helps one to understand their clinical advantages and disadvantages.

Clinical Conditions

Training

Prerequisites. Practitioners have varying degrees of prior experience that may influence the ease with which they can prepare to perform mainstream implant dentistry treatment, including implant insertion and/or prosthodontic restoration and professional maintenance. Practitioners who, in the course of normal events in their practice, remove teeth and place sutures a few times each year, and now and then perform minor gingivectomies, routine fixed prosthodontics, and single-root endodontic treatment have the prerequisite skills necessary to perform mainstream implant dentistry following required additional training.

These prerequisite skills are sufficient. Countless practitioners who possess these skills have already been trained to treat mainstream implant dentistry cases. At the beginning of one's learning curve, it is prudent to avoid attempting cases that are too complex. The key is to practice at the level to which one has been trained. First and foremost, one must learn to recognize a mainstream case and limit oneself to treating such cases until they cease to be challenging.

Conventional Training Policies. Unspoken principles of training that are taken for granted in other areas of dental treatment are also applicable in implant dentistry. Students do not have to be able to perform complete arch rehabilitation, or fabricate a 10-unit fixed bridge, before

they can treat a buccal pit or occlusal restoration. One starts at the beginning and progresses step by step until reaching one's natural level of comfort, competence, and expertise. At any level, there is plenty to do. Even if one wishes only to treat the most basic cases, in implant dentistry such treatment can be provided for most implant dentistry candidates.

Training Requirements for Mainstream Applications. Most practitioners worldwide who currently practice multimodal implant dentistry started with one modality after completing a 2- or 3-day training course.²⁸ The same is true of mainstream treatment involving bonding, laminates, and some new periodontal and endodontic procedures. The training required varies according to the modality or system, but not widely.

Acceptable Total Number of Patient Visits and Elapsed Weeks in Treatment. The elapsed time of treatment has much to do with both professional and patient acceptance of any course of treatment. The step-by-step teaching case chapters detail the elapsed time requirements for mainstream treatment with each of the abutment-providing modalities. This is an important consideration for many patients, who generally wish to conclude treatment as quickly as possible.

Ability to Incorporate Treatment into Conventional Office Routine. If treatment using a modality or system requires so much time at a given visit, or is so complex or technique-sensitive that it disrupts the office routine, then it may not be suitable for incorporation into general practice. Mainstream implant dentistry treatment must be easily incorporated into the general practice of dentistry. The mainstream applications demonstrated in the teaching cases in this book are relatively easy to incorporate into one's daily routine. Some modalities and systems currently available do not meet this requirement. A simple look at the flowcharts of components and elements required for various systems demonstrates this point.

Acceptable Start-Up, Implant, and Component Costs. Because of the lack of uniformity associated with some systems, or perhaps because of technique-sensitivity, certain systems' start-up costs inhibit general acceptance. The necessary basic instrumentation, implants, and components should be affordable. They should represent a good investment.

Implant and component costs ultimately affect the fee charged to the patient, sometimes to the point that the patient is not able to afford the treatment. Costs are a legitimate consideration for both the practitioner and the patient.

Ability to Use Conventional Prosthodontics

Technique-Sensitive Restorative Treatment. Prosthodontic requirements are a key concern for every practitioner involved in implant dentistry and a prime deterrent for many who are not yet involved. In the case of some root form systems, it became necessary to reconceive prosthetic dentistry, to perform routine restorations.²⁹ Manufacturers, dental societies, and universities have instituted courses limited to the prosthodontic restoration of root form cases to address this issue.

Restorative procedures can be complex because many root forms are submerged for a functional healing to permit osseointegration. This means that no attachment or abutment component protrudes through the gingiva during healing. Therefore, a receptor site exists within the implant body into which attachment components for prostheses are secured. Because the long axis of implant insertion most often is not at the angle required for prosthodontic parallelism, achieving parallelism requires the mastery of additional skills. Also, splinting presents new concerns. A high degree of accuracy is required, because the healed root form implant is rigid, and therefore the overlying framework may not seat properly if even a slight discrepancy exists. There is no natural accommodation of the type commonly observed when placing a conventional fixed bridge over natural teeth or healed osteopreserved implants, which are resilient. In addition, lack of passiveness may cause retention screws to loosen or fracture. Difficulty in achieving acceptable esthetics and problems in administering professional and home care are other restoration-related difficulties that have been reported.

For these reasons, per-unit laboratory fees for root form restorations can be double what is charged by the same laboratory for conventional fixed bridgework. In addition, more hours of chairside and laboratory time are required to complete a case.

Root form manufacturers deal with these difficulties with varying degrees of success. The Innova Endopore root form system used in this book offers some of the best resources to avoid or handle restorative difficulties,³⁰ and the immediate-impression Nobel Biocare/Steri-Oss system used for the complete overdenture teaching case and the Frios-2 system used for the anterior single-tooth replacement teaching case in this book show high degrees of restorative simplicity.³¹

Conventional Restorative Treatment. Osteopreserved plate/blade form implants and periosteally integrated subperiosteal implants are restored conventionally. The fixed prostheses are affordable at the laboratory, completed quickly, require little or no extra training, provide excellent esthetics, and can be routinely maintained professionally. Home care cleansing follows the same procedures indicated for conventional bridgework. The implant abutment is simply treated as though it were a natural tooth abutment for impressions, bite registrations, home care, and the like.

Ability to Use Implant for Single-Tooth Replacement. Single-tooth replacement is a benefit that currently is available only with the root form modality. It is a mainstream procedure. Although conventional restorative dentistry can effectively treat the interdental loss of a single tooth, use of a root form implant for single-tooth replacement avoids reduction of the adjacent teeth so they can be preserved when they are healthy, esthetic, and in functional occlusion. Anteriorly, esthetic considerations are very important. When the **emergence profile** regimen is followed, this treatment becomes more difficult, and the crown-root ratio may be reduced.

The advantage of not needing to reduce adjacent teeth is a benefit in interdental cases in any area of the oral cavity.

Compatibility With Natural Co-Abutments. Ideally, an implant modality should be able to function in a mode of tissue integration that is compatible with the use of natural co-abutments under a prosthesis. All of the abutments supporting an intraoral prosthesis should have biomechanically equivalent tissue integration. In complete arch cases supported entirely by implant abutments, all of the abutment-providing modalities can be used successfully. In such cases, the restoration must be supported entirely by osseointegrated or by osteopreserved and/or periosteal integrated implants. Natural abutments, osteopreserved implants, and periosteal integrated implants are biomechanically compatible under a fixed prosthesis. Chapter 6 details the biomechanical principles of the three modes of tissue integration.

In cases in which teeth must be splinted to each other under a fixed restoration for periodontal reasons, a distal implant to help support the splinted prosthesis should be osteopreserved or periosteally integrated.

Ability to Use Preexisting Available Bone. In ideal mainstream cases, a dental implant system can use existing healed alveolar bone and attached gingiva. In cases in which either of the two endosteal modalities may be used but one would require extensive bone augmentation and/or subantral augmentation, ridge expansion, or nerve repositioning, one should use the modality that provides mainstream treatment without need for these ancillary procedures. Every additional step has a potential for complications.

Peri-Implant Indices Comparable With Periodontal Indices. The ideal implant modality should have peri-implant indices comparable with the periodontal indices accepted by the profession. Pocket depth, mobility, and presence of attached gingiva are important factors bearing on the prognosis of an implant, and on the esthetics and prognosis of the restorative treatment. One of the most important seminal studies on the root form modality reported high percentages of unattached vestibular gingiva.^{32,33} Soft-tissue pockets, especially in areas of unattached gingiva, have been associated with root form implants because of difficulties in ensuring the presence of attached gingiva directly over submerged implants. Pocket depths are further increased when emergence profiles are used. Plate/blade form and subperiosteal implants have been shown to have comparatively higher percentages of attached gingiva and diminished pocket depths. Plate/blade forms have resilience similar to that of the natural co-abutments. Root forms have zero clinical mobility, and in that respect are akin to ankylosed teeth. The resilience of plate/blade forms has been shown to incrementally decrease over time.^{8,34}

Adequacy of In-Office Radiography. For mainstream implant dentistry treatment, the information provided by periapical radiographs normally is sufficient. Panoramic radiographs can be useful but are not essential.

Magnetic resonance imaging (MRI), **computerized axial tomography (CAT)**, and other computer-generated images may be required in more complex cases but are not necessary in mainstream cases. Recall that in mainstream cases, available bone width is clinically determined to be adequate and that periapical radiographs clearly show the location and extent of available bone length and depth.

Ease of Sterilization and Maintenance of Sterility.

Dental implants and their components are either delivered specially packaged and sterile or are prebagged for ease of in-office sterilization. Achieving sterility is easy. Many practitioners desire the ability to resterilize. Uncoated machined or coined implants can be cleansed, rebagged, resterilized, and reused after a try-in in cases in which another configuration is selected.

Routinely Achievable Esthetics. Esthetics is an important consideration for the patient and practitioner alike. The esthetics associated with the plate/blade form and subperiosteal implant modalities are routinely ideal. The esthetics associated with root form implants can be more challenging to achieve.³⁵ The key to achieving acceptable esthetics lies in the ability to ensure that at least the vestibular tissue around the healed implants is attached gingiva to permit esthetic **ridge lapping**.

Influence of Gross Anatomy of Healed Ridges. When teeth are removed and the healing process of the partially or totally edentulous alveolar ridge is complete, bone loss has occurred at the expense of the crest of the ridge and the buccal/labial plate. Thus, the crest of the healed ridge is lingual to where the incisal edges or central fossa of the natural teeth were when they were in position. The implant abutment that arises from the healed crest will almost always be toward the lingual of the restorative crown. Ideally, the original interocclusal relationship should be restored, particularly in esthetic areas.

Preservation of Attached Gingiva. Generally, the band of attached gingiva is 3 to 7 mm wide bucco/labiolingually. This region of attached gingiva can be conserved and placed along the buccal/labial pergingival margins of the healed implant abutment by suturing it into the desired position at the time of insertion when using a nonsubmerged implant. Thus, when possible, root forms and plate/blade forms case-sequenced for osseointegration should be semi-submerged at insertion. If submerged, the overlying gingiva and therefore the final positioning of attached gingiva cannot be as easily controlled.³⁶ Using the semi-submerged option, the healing collar on the inserted implant is positioned flush with or up to 1 mm above the gingival crest. The attached gingiva is positioned carefully around it, surgically prepared for ideal contour, and sutured, ensuring its presence at the implant gingival margins.

Relationship Between Attached Gingiva and Esthetics—the Ridge Lap. The presence of attached gingiva allows one to ridge lap the labial or buccal of a restoration over an implant.³⁷⁻³⁹ The advantages of doing so are significant. Ridge lapping cannot be performed for a restoration over a tooth because this may cause periodontal complications,

possibly because the fibers at the base of the gingival sulcus insert into cementum. This is not the case with implants. When the transgingival surface of a healed implant is in attached gingiva, the pergingival site has been shown to remain healthy when proper home care is followed.⁴⁰ Home care is not difficult to perform.

The ridge lap simply extends the buccal/labial aspect of a restoration to a position and contour more appropriate for esthetics and cleansability.³⁸ This promotes esthetics in the same manner as a ridge lap on a pontic of a fixed bridge. The ridge lap gives the tooth the appearance of a normal gingival lineup and makes the restoration appear to be growing from the gum. An additional benefit is the ability to achieve a closer-to-ideal occlusal relationship because of enhanced tooth contouring. Any professionally accepted abutment-providing implant modality can be ridge lapped if its final abutment protrudes through attached gingiva. Hygienic maintenance is easily performed by the patient, as taught in the step-by-step treatment chapters.

Emergence Profile for Esthetics. A root form implant may need to take advantage of the emergence profile concept, especially in the anterior maxilla.³⁵ To enhance anterior esthetics, the emergence profile requires an increased depth of gingiva between the gingival crest and the alveolar ridge crest. If desired tissue depth is not present, it is created by **ramping** crestal bone at the time of insertion, thus reducing the depth of available bone and increasing the crown/root ratio. In this case, the connection of the restoration to the implant will be beneath the gingival crest, at the reduced level of the crest of bone. As the restoration rises through the deepened gingiva, it widens and extends labially until it emerges as what appears to be a properly dimensioned tooth in an esthetic location. This procedure is technique-sensitive but under appropriate conditions can be considered mainstream.

Strong, Standardized, Interchangeable Components. Standardization of components is another desirable consideration. It would be an advantage if all implant system components were interchangeable. Establishing uniformity and simplification of sizes and components is required to bring implant dentistry into the great majority of dental offices, and is an important consideration for practitioners.

Ease of Professional and Home Maintenance. Ease of maintenance is another requirement for the ideal implant modality. For systems that use conventional restorative dentistry, maintenance is not a problem. Professional maintenance by a practitioner or hygienist is performed as for conventional prostheses and can be just as effective. In the case of ridge lapping, use of the Hydro-Floss system has been shown to be an advantage, and, of course, routine flossing is also performed as a part of home care.⁴¹

Because of the complexity of the substructure or superstructure, splinted root form restorations can be a bit more difficult to maintain. These cases require more frequent professional maintenance and diligent home care. Use of a Hydro-Floss is also valuable for such cases.

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8 Seminal Studies of the Safety and Efficacy of the Abutment-Providing Implant Modalities

In the history of implant dentistry, certain published reports on the safety and efficacy of implant systems have been instrumental in achieving widespread professional acceptance not only for the system under consideration but also for its modality and the discipline in general. This chapter identifies and reviews some of the seminal reports that provided the evidence, and thus the confidence, required for widespread usage of dental implants. The results are presented, as well as an overview of some of the methodology of these clinical trials. The studies discussed are not presented in exhaustive detail; rather, essential elements of each study are highlighted to convey the aspects that made it seminal.

The studies discussed herein are not the only important investigations to have been conducted in implant dentistry. They were chosen because at the time of their publication they broke new ground. Several of them were directly responsible for achieving American Dental Association (ADA) acceptance of the system under investigation. Interested readers are encouraged to examine the original reports and to peruse journals regularly for new developments.

Some studies included in this chapter are not as widely known. A good example are the studies related to subperiosteal implants. For some of the modalities and systems described in this book, no single clinical trial dramatically influenced the profession. Subperiosteal implants were the first type of implant to be used broadly and therefore have a decades-long history of usage. Because the implants themselves are custom-made and thus cannot be standardized, creating a clinical trial protocol that sufficiently limits variables is difficult. The studies of the subperiosteal implant modality presented in this chapter were chosen because they are among the best available given the challenges inherent to evaluating this type of implant.

The best policy is always to go straight to the source to analyze scientific research. Whenever research is interpreted by a third party, some of its original meaning can be lost. Popular opinion about science has varied cyclically in the history of implant dentistry. Implant systems and even modes of tissue integration have passed into and out of vogue. Going straight to the source of the scientific research conducted on these subjects helps one avoid accepting common misconceptions and myths as scientific truth.

Chapter 7 discusses the relative value of different types of scientific investigations. As a rule, the classic model of the prospective, independent, longitudinal, controlled, randomized clinical trial provides the highest confidence level of any type of scientific investigation.¹ Proper serial and retrospective studies also have considerable value. It is almost impossible for a clinical trial to be conducted perfectly. Nonetheless, without exception, the studies presented in this chapter are important given the impact they have had on our profession.

A comparative review of implant investigations is made more challenging by the fact that the success criteria tend to differ study by study. In most studies, success criteria are defined by the investigators. Success criteria can be stringent or lax, for example, in the measurement of periodontal indices.² Ideally, when using success rates, the criteria for success should be defined before the study commences, and then strictly followed.

Conforming success rates for comparative analysis between studies with different success criteria, or for collation of the results of several studies, is challenging and of questionable validity. To compare two investigations with different success criteria, one would need either to use the success criteria of one or the other study, or define new success criteria and then conform the data of both studies. However, choosing between the success criteria of two

studies entails making an implicit judgment regarding which set of criteria is “correct.”

One way to compare the results of studies regardless of success criteria is to use survival rates. Survival rates are simple and basically not open to interpretation. At a specific point in time, if an implant is functioning for its intended purpose, it counts as a survival. If the implant is not functioning for its intended purpose, it has not survived. The implant’s survival is independent of whether it experiences reversible complications in the course of the study. The beauty of using survival rates for comparison or collation is that the data of any study, regardless of its protocol, can fairly be conformed into survival data.

The examination of seminal studies that follows is treated modality by modality. The discussion of each clinical trial begins with how it was conducted, the number of subjects, its timeframe, and any other factors necessary to understand the results. Next, the results and their importance are discussed.

INVESTIGATIONS OF BONE LOSS IN UNIMPLANTED ALVEOLAR RIDGES

Loss of bone height over time around implants is one of the most important factors examined in most implant studies. This consideration naturally leads to the question: How much bone loss is acceptable? Ideally, one would like to see no bone loss whatsoever. However, this is unrealistic. A natural point of reference is: How much bone is lost in an unimplanted ridge? If the amount lost after implantation is less than the amount that would have been lost in the absence of implantation, then implant dentistry can truly be said to be preventive.

Extensive longitudinal studies have clearly demonstrated that resorption of the alveolar ridge following tooth loss is generalized, progressive, irreversible, and deforming.^{3,4}

Following tooth loss, a quantitative deficit of 75% occurs in the tissues that support the masticatory load. Therefore, conventional dentures that are supported by the mucosa over the residual alveolar ridge cannot be expected to function in the same manner as natural teeth. A chief concern with dentures is the tissue changes that occur under them. Innumerable studies have examined alveolar bone loss in such cases.^{3,5,6} Studies have highlighted the rate of bone loss associated with various types of dentures and in different treatment situations⁷ (Fig. 8-1).

Some studies have also investigated how this bone loss can be retarded. Before the use of endosteal dental implants, little progress had been made to mitigate this natural process.

Resorption progresses until portions of the buccal and lingual cortical plates approximate. The alveolar bone develops with the eruption of teeth, and in time almost entirely disappears with their loss.

A challenging effort in prosthodontics is to follow the Axiom of De Van, which states that preservation of what remains is preferred to meticulous replacement of what is missing. Restorative procedures have always been guided by this principle, which remains the standard for weighing

benefits and risks. Endosteal implant treatment helps to preserve what remains of alveolar bone height and width.

To demonstrate that implant treatment is preventive, a clear and concise baseline of quantifiable bone loss over time in unimplanted healed partially and totally edentulous alveolar ridges is required. This also aids in the assessment of benefit and risk related to bone maintenance around the implant modalities and systems covered in this book.

Tallgren³ noted that “the resorption of the residual alveolar ridges during a 7-year period of denture wear was found to have caused a pronounced reduction of the preextraction morphologic face height and an accompanying although less marked reduction in the rest face height . . . With the continuing resorption over the years, the prosthetic replacement of the lost tissues will give rise to increasing treatment problems and may cause the patient extreme difficulties in management of the dentures. The continuing resorption, especially of the lower ridge, therefore, constitutes a serious prosthodontic problem.”

Atwood⁴ noted that “the primary structural change in the reduction of residual ridges (RRR) is the loss of bone. The rate of reduction and the total amount of bone removed in this disease vary from individual to individual, within the same individual at different times, and even at the same time in different parts of the ridge . . . Because RRR is chronic and progressive, it results in repeated mucosal, functional, psychologic, esthetic and economic problems for denture patients. Because it is cumulative, the patient with this disease becomes more and more dentally handicapped, ultimately a ‘dental cripple’.”

Cephalometric studies by numerous authors worldwide have shown that mean rates of residual ridge resorption are remarkably consistent³⁻⁵ (Fig. 8-2).

In another study, 34 denture patients were studied over a 5-year period. Change in rate of bone loss was observed relative to time postextraction, as well as the range of variation from the mean⁸ (Fig. 8-3).

Bone loss of the residual ridges has always been a problem both for the practitioner and the patient. It is a natural process, independent of the restorative procedure. It may be true that faulty dentures tend to increase the rate of resorption. For more than 50 years, design variations of conventional removable dentures have failed to halt this irreversible bone loss, although methods for preservation of the residual ridges have been recognized and practiced.⁹

The practical significance of this progressive bone loss is that removable dentures that are used to substitute for missing teeth depend on the bony support of the residual ridge for stability, retention, comfort, function, and esthetics. If the bony base constantly changes shape over time, even well-constructed dentures become unsatisfactory and require multiple retreatments to restore comfort, function, and appearance.

Both systemic and local etiologic factors have been suggested, and a consensus has developed that alveolar ridge resorption in unimplanted ridges is of multifactorial origin. No treatment except for endosseous dental implantation has demonstrated preservation of the ridges.

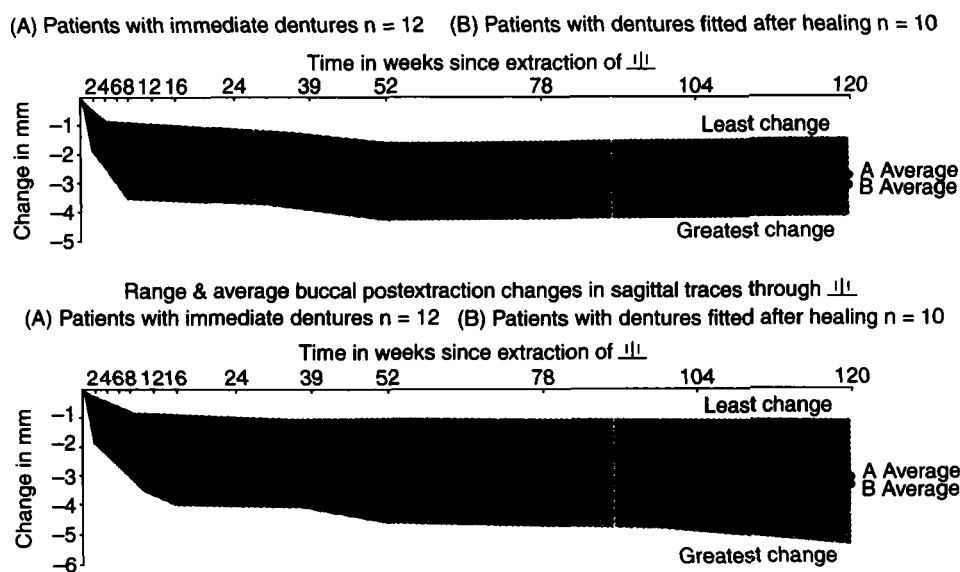


FIG. 8-1 ■ Postextraction changes in ridge height and buccal contour in incisor region under conventional and immediate dentures. (From Watt DM, Macgregor AR: *Biometric guides to the design of complete dentures*. In Watt DM, Macgregor AR, editors: *Designing complete dentures*, ed 2, Bristol, England, 1986, Wright.)

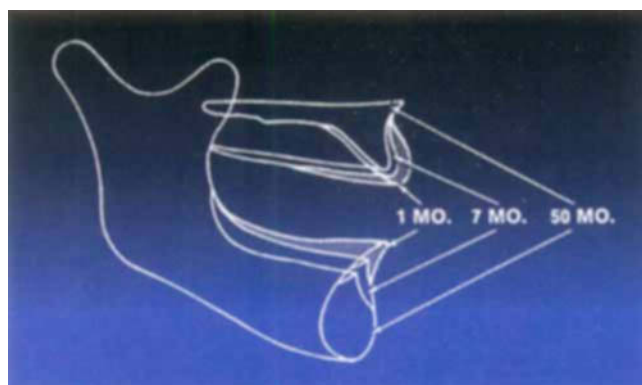


FIG. 8-2 ■ Tracings of three lateral cephalographs with maxillae and mandibles superimposed. (From Atwood DA: *J Prosthet Dent* 13:811, 1963.)

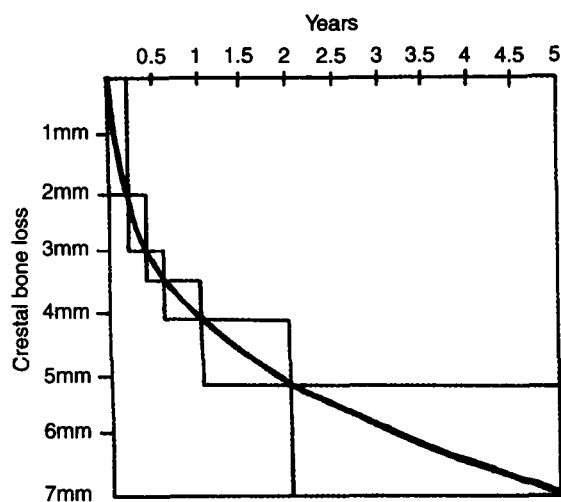


FIG. 8-3 ■ Rate of crestal bone loss (mm) in unimplanted edentulous alveolar ridges.

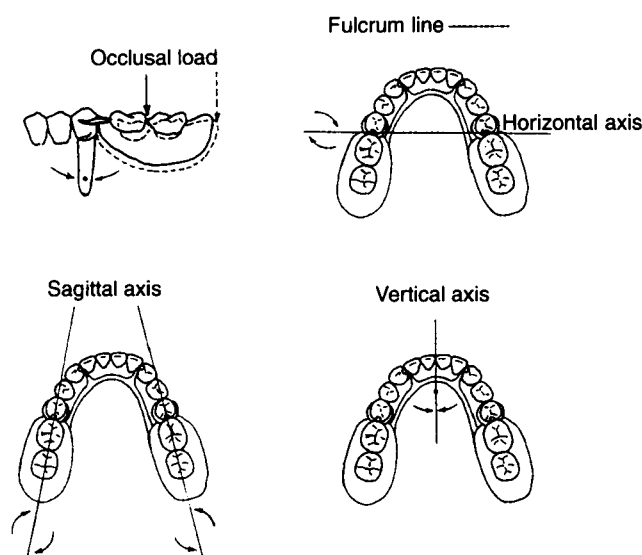


FIG. 8-4 ■ Forces acting on a partial denture in typical Kennedy Class I situation.

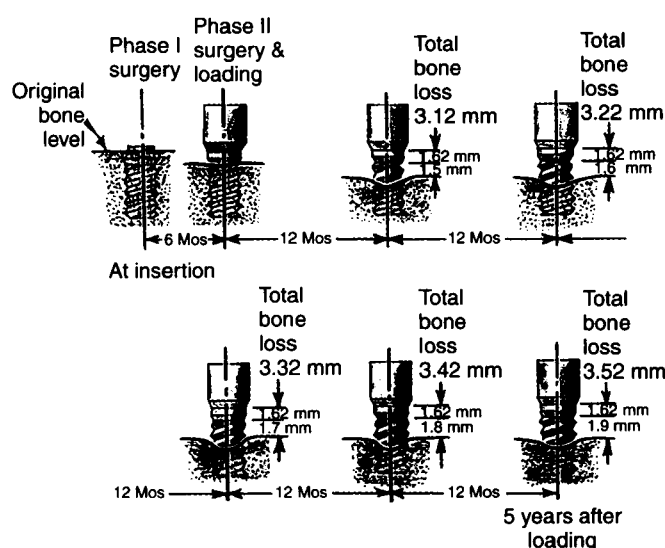


FIG. 8-5 ■ Rate of crestal bone loss (millimeters) in ridges implanted with screw-type root form implants in Göteborg study.

Carlsson, Hedegard, and Koivumaa⁵ noted that “a statistical comparison of the means [of bone loss] for denture wearers and non-denture wearers showed a significantly greater reduction in the marginal bone for the former group on both mesial and distal aspects . . . This is probably ascribed to (1) direct pressure on the underlying bone exerted by the partial denture, and (2) to the deleterious effects of the partial denture on the periodontal tissues of the abutments, which was evident from the clinical study.”

Kelly¹⁰ noted that “complete lower dentures opposing natural maxillary teeth are impossible prosthodontic combinations. Treatment planning should avoid the necessity for such a combination. The same could be done to eliminate the combination of complete upper dentures opposing Kennedy Class I lower partial dentures.”

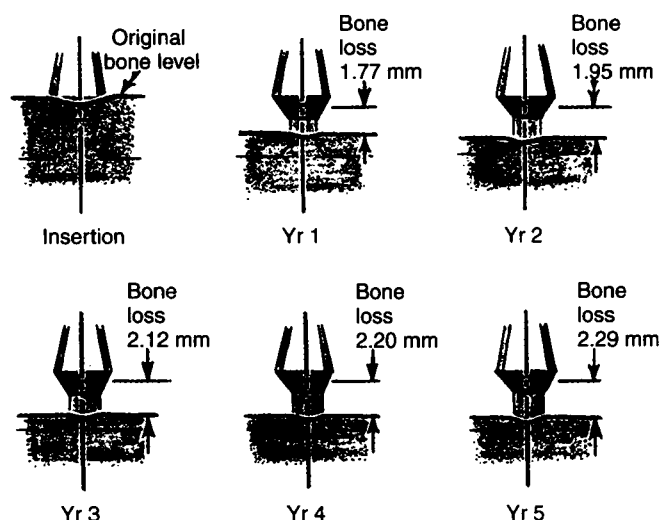


FIG. 8-6 ■ Rate of crestal bone loss (millimeters) in ridges implanted with plate/blade form implants in VA study.

Regarding gingival status, Carlsson noted the percentage of abutments with inflammation of the gingiva rose significantly, from 13% at the time of denture fabrication to 65% after 1 year and 68% after 4 years. Regarding depth of the gingival pocket, the incidence of abutments with deepened gingival pockets in denture wearers was observed to increase from 14% to 25% at 4 years. In addition, the incidence of teeth with exposed cemento-enamel junctions was observed to increase, and 41 of 44 abutments without crowns showed decay during the 4-year follow-up period.⁵

Free-end saddle removable partial dentures use combined tooth-tissue support. Because of the use of clasps, indirect retainers, major connectors and the like, they tend to accumulate plaque, increasing the incidence of periodontal disease and caries. These Class I and II situations also increase the risk of abutment loss.

Moreover, tooth-tissue borne dentures are subjected to forces acting through fulcrum lines along three axes (Fig. 8-4). These deleterious forces are constantly exerted laterally, obliquely, and apically over the ridges under removable partial dentures. Ridges cannot physiologically absorb these stresses and therefore resorb under function. Hence, repeated relines under dentures become necessary.

Dental implants provide fitting solutions to these complex problems. The use of implants not only conserves bone that would have been lost if unimplanted but also enhances the overall quality of the treatment provided.

Within the context of this book, the primary point is to be able to compare the rate of bone loss in unimplanted ridges to that in implanted ridges. Compare the mean 7-mm bone loss at 5 years in unimplanted ridges according to Carlsson, Hedegard, and Koivumaa⁵ with that around root form implants according to the study by Adell, Lekholm and Rockler¹¹ (Fig. 8-5) and that around plate/ blade form implants according to the Veterans Administration study¹² (Fig. 8-6), both of which are discussed in detail herein. Note that the root form data do not include bone loss resulting from

ramping that often is required preimplantation to achieve sufficient ridge width for implant placement. At all times the cumulative bone loss remains significantly lower after endosteal implantation than in unimplanted ridges.

SEMINAL ROOT FORM INVESTIGATIONS

University of Goteborg Nobelpharma Study

The publication of the original research conducted by the Branemark team on their “fixture” root form implants influenced the dental implant profession more profoundly than any published investigation before or since.¹³ It marked the first time that a published study on dental implants had the appearance of hard science, performed in a university setting, using empirical standards. The publication of this research catalyzed an explosion in the use of the root form modality.

The study, conducted at the University of Goteborg in Sweden, began in 1965. Several articles reported updates. In 1981, a report of “a 15-year study of osseointegrated implants in the treatment of the edentulous jaw” was published in the *International Journal of Oral Surgery* and became the most significant of the articles related to the study. Hereafter, the study is referred to as the Goteborg study.¹¹ Together with the replica study conducted at the University of Toronto, the Goteborg study was chiefly responsible for achieving ADA acceptance of the Nobel Biocare Brånemark Fixture Implant System.

Type of Study. The Goteborg study was a wide-scale serial study, in which the investigators serially performed a procedure on numerous consecutive subjects and reported the results. This study was not independent, insofar as it represented the analysis of an implant system by its own developers. No control group was used, because comparing results between recipients of the implants and patients who remained edentulous was not part of the objective. This precluded the possibility of randomization. The data were presented as longitudinal but require some analysis and backward derivation to account for all study subjects at each measurement interval.

The value of the Goteborg study is in its large scale and in the fact that it broke new investigative ground. The impact of this study on implant dentistry as a discipline cannot be overstated.

Study Population. Between 1965 and 1980, 2768 root form implants were inserted into 410 totally edentulous jaws of 371 consecutive patients. The study population was divided into three chronologic groups. The first was a pilot group, in which the “surgical and prosthetic technique was developed and evaluated.” The remaining subjects were analyzed separately in two groups—those who could be followed for 1 to 4 years after insertion and restoration, and those who could be followed for 5 to 9 years after insertion and restoration. The 5- to 9-year study group was considered to be the most representative of long-term results using the implant system under consideration. The population of this 5- to 9-year group was 130 edentulous arches treated and restored using 895 osseointegrated root form implants.

Extent of preoperative resorption of the alveolar ridge was not a criterion for patient selection, and the study population showed a broad range, from moderate to complete alveolar ridge resorption. In the opposite arch, 38% of patients had natural teeth or bridges supported by natural abutments, 10% had removable partial dentures, and 52% had total dentures.

Treatment Procedure. Because no control group was used in this study, the same basic procedure was performed for each subject. Usually, six osteotomies were prepared between the mental foramina in the mandible or between the anterior walls of the sinuses in the maxilla. Osteotomy drilling was performed using spiral drills of incrementally increasing diameter at a speed of approximately 1500 revolutions per minute (rpm). Bone drilling was conducted with a minimum of torque force and under profuse coolant. After the implants were inserted, they were fitted with cover screws and the tissue flaps were sutured over the implanted osteotomies for submerged healing. The patient was put on a soft diet for 1 week postoperatively.

Afunctional healing in the mandible was allowed to progress for 3 to 4 months, and in the maxilla for 5 to 6 months. After the healing period, the implants were uncovered using a punch to excise the gingiva covering each implant. Cover screws were removed, and abutments were attached to the implants.

Prosthodontic restoration was performed approximately 2 weeks following the attachment of abutments. All bridges were screw-retained. The bridges included a maximum of two teeth cantilevered distal to the most posterior implant on each side in the mandible, and one tooth distal to the most posterior implant on each side in the maxilla.

Postoperative examinations were conducted every 3 months during the first year after restoration and at least annually thereafter. Peri-abutment tissues, occlusion, bridge stability, and stress distribution were examined. Some consecutive patients with fewer than 5 years of follow-up underwent a more thorough examination of plaque and gingival indices, clinical pocket depth, and changes in marginal bone height. For all patients, the first radiographic examination was conducted 1 week after abutment attachment (4 to 9 months after implant insertion), and subsequent radiographic examinations were performed 6 and 12 months after abutment attachment. Thereafter, radiographs were checked at least once a year to determine loss of bone height. Roentgenograms taken during the early period of the study that were deemed to have sufficient clarity and contrast for analysis were also used.

Results

Success/Survival Rates. The Goteborg study reported survival data separately in the mandible and maxilla at 1 year, 3 years, and the entire period for the group that was followed between 5 and 9 years (Table 8-1).

The survival rate of the supported prostheses was also noted over the entire follow-up period. Bridges that were not continuously stable were counted as failures (Table 8-2).

Of the bridges counted as survivals, Table 8-3 shows which required supplementary installation of additional

TABLE 8-1 UNIVERSITY OF GÖTEBORG STUDY
IMPLANT SURVIVAL RATES

Arch	Time	Implant Survival
Maxilla	1 yr	84%
	3 yr	82%
	Entire period	81%
Mandible	1 yr	91%
	3 yr	91%
	Entire period	91%

TABLE 8-2 UNIVERSITY OF GÖTEBORG STUDY
PROSTHESIS SURVIVAL RATES

Arch	Prosthesis Survival
Maxilla	89%
Mandible	100%

TABLE 8-3 UNIVERSITY OF GÖTEBORG STUDY
PROSTHESES CONSIDERED AS SURVIVALS
REQUIRING ADDITIONAL IMPLANT INSERTIONS

Arch	Number of Surgeries	Percentage of Total
Maxilla	1	16%
	2	3%
	3	2%
Mandible	1	3%
	2	6%
	3	0%

TABLE 8-4 UNIVERSITY OF GÖTEBORG STUDY
MARGINAL BONE HEIGHT LOSS

Arch	Interval	Bone Loss from First Thread
Maxilla	Healing period	1.3 mm
	1 yr	0.2 mm
	Yearly average	0.1 mm
Mandible	Healing period	1.0 mm
	1 yr	0.4 mm
	Yearly average	0.1 mm

TABLE 8-5 UNIVERSITY OF GÖTEBORG STUDY
COMPLICATIONS IN 5-9 YEAR GROUP

Arch	Time	Percentage With Complications
Maxilla	Healing period	20%
	Bridge loaded period	16%
Mandible	Healing period	15%
	Bridge loaded period	13%

implants to maintain continuous bridge function. Thus, the necessity of implant removal and reinsertion did not influence the survival criteria for the prosthesis as established by the investigators.

Bone Height. Crestal bone height loss was first observed by radiographic examination at the end of the healing period, defined as the period between implant insertion and restoration, and then annually postrestoration (Table 8-4).

Peri-Implant Tissues. Soft tissue around the implants was also examined. In the cases examined more extensively for peri-implant tissue complications 1 year after abutment attachment, the gingival index, defined as the percentage of peri-implant quadrants exhibiting gingivitis, was 13.7%, and the plaque index, defined the same way, was 7.6%.

Mobility. Because the implants were osteointegrated, clinical mobility was zero. When clinical mobility was noted, it was considered a complication, as discussed in the following section.

Complications. The incidence and causes of complications were also analyzed in 304 implants in 22 maxillas and 24 mandibles of 43 randomly selected patients. Complications were defined as loss of osteointegration because of surgical trauma, functional overloading, or progressive crestal bone loss. Measurements were taken at the end of the healing period, and at a "bridge loaded period" of undefined interval. The data shown in Table 8-5 are for the group followed up for 5 to 9 years.

Gingival complications were defined as proliferative gingivitis, observed in association with 6.7% of implants, and fistulas, observed in association with 1.5% of implants. Mechanical failure, defined as fracture occurring 1 to 6 years after implant insertion, was observed in 3.5% of inserted implants. Implant fracture was associated with accelerated crestal bone loss. In a sample of 326 implants followed specifically for crestal bone loss, 8% were found to have crestal bone loss of 3 mm per year. In each of these cases, fracture of the implant or the bridge was noted. Fracture was presumed to result in unfavorable force distribution to induce the bone loss. Fracture of bridges occurred in 4.9% of cases, of prosthesis retention screws in 1.5% of implants, and of abutments in 3.0% of implants.

Analysis. The Göteborg data are subdivided in a way that makes comprehensive analysis challenging. The

15-year duration of the study is subdivided into three periods, a 5-year pilot period during which the surgical and restorative protocols were standardized, study period 1 during which 5 to 9 years of follow-up data were collected, and study period 2 during which 1 to 4 years of follow-up data were collected. Cross-sectional samples comprised of portions of each of these three study groups were considered separately for peri-implant bone loss, complications, and gingival health.

James et al¹³ pointed out that clinical trials commonly measure all failures from the day of implant insertion, whereas the Goteborg study eliminated early failures from statistical consideration in the results data. Early failures were those that occurred within 1 year of insertion and restoration. With these early failures accounted for, James calculated that the survival rate in the maxilla dropped from 81% to 70%, and in the mandible from 91% to 76%.

Another aspect of the Goteborg data that requires special attention is that bone loss related to the removal of crestal bone height to achieve sufficient ridge width for osteotomy preparation is not reported. On a purely scientific level, the ramping required to insert the implant may not be strictly relevant to an analysis of the effect of implant insertion on marginal bone. However, on a clinical level, knowing how much bone must be removed preinsertion is vital. Evidence that ramping was required can be found in the original Goteborg study figures, but the amount of ramping is not quantified. In the case of 3.75-mm root form implants of the system used in the Goteborg study, at least 2 mm of ramping usually is required before implant insertion is possible (Fig. 8-7).

Aside from this preinsertion bone loss, the loss that occurred during the healing phase was not accounted for, because immediate postoperative radiographs were not taken "to avoid possible negative effects of diagnostic x-rays on the differentiation of healing bone tissue." Radiographs taken after abutment attachment served as the baseline for future comparison. Bone loss reported for the "healing period" was measured from the first thread closest to the ridge crest. However, at the time of insertion, the superior surface of the implant was flush with the ridge crest. Thus, to determine the amount of bone loss during the healing period, one must add the distance between the superior surface of the implant and the first thread on the implant. This represents 1.62 mm that presumably was lost between implant insertion and the initial radiographic examination after abutment attachment (Fig. 8-8).

Thus, in accounting for the approximately 2 mm of preinsertion bone ramping performed to obtain required ridge width, and for the 1.62 mm of bone loss unreported during the healing period, one may add 3.62 mm to all measurements of bone loss in this study.

Over the course of the study, 21% of the maxillary cases and 9% of the mandibular cases required implant removal and reinsertion to maintain continuous prosthesis function. If these prostheses are considered failures rather than successes because alteration or adaptation was required to accommodate the position of the additional implant(s),

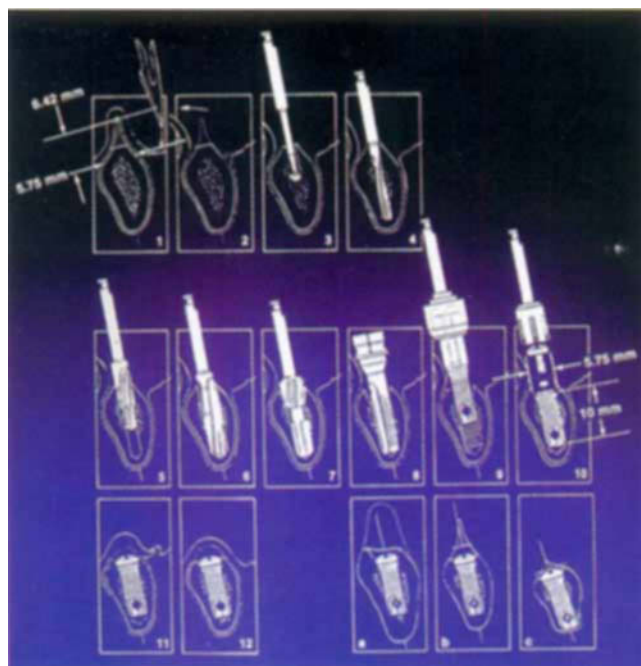


FIG. 8-7 ■ Ramping bone loss associated with screw or cylinder-type root form insertion. (Modified from Branemark PI, Zarb GA, Albrektsson T, editors: *Tissue-integrated prostheses: osseointegration in clinical dentistry*, Chicago, 1985, Quintessence.)

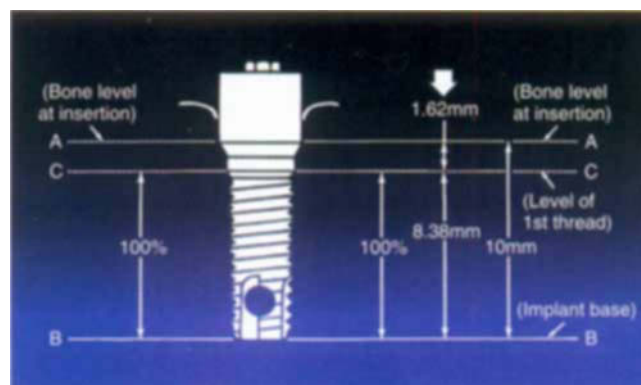


FIG. 8-8 ■ Bone loss of 1.62 mm from ridge crest to depth of first thread of fixture between insertion and radiographic evaluation in Goteborg study. (Modified from Branemark PI, Zarb GA, Albrektsson T, editors: *Tissue-integrated prostheses: osseointegration in clinical dentistry*, Chicago, 1985, Quintessence.)

then the prosthesis success rates drop from 89% and 100% to 68% and 91% in the maxilla and mandible, respectively.

Notwithstanding the difficulty of analyzing the Goteborg data, the sweeping scale of the study clearly demonstrated to the profession at the time of publication that the root form implant was safe and effective for its intended purpose of providing additional abutment support for restorative dentistry. Subsequent studies offered additional validation of the use of the modality, and as with every surgical procedure, success/survival rates increased

TABLE 8-6 UNIVERSITY OF TORONTO REPLICA STUDY IMPLANT SUCCESS RATES

Number of Implants Placed (Not Including Sleepers)		Number Lost	Number of Sleepers	Successful Implants
Upper	12	0	0	12
Lower	132	18	7	114
TOTAL	144	18 (12.5%)	7	126 (87.5%)

TABLE 8-7 UNIVERSITY OF TORONTO REPLICA STUDY BONE LOSS

Time	Surface	Number of Surfaces	Bone Loss (mm)	Standard Deviation	Minimum	Maximum
Year 1	Mesial	87	1.64	0.551	0.37	3.69
	Distal	86	1.63	0.549	0.67	3.80
Year 2	Mesial	82	0.16	0.495	-2.16	1.63
	Distal	81	0.08	0.460	-1.89	1.62
Year 3	Mesial	44	0.14	0.367	-0.63	0.90
	Distal	40	0.12	0.376	-0.03	1.03

over the years as the surgical, healing, and restorative protocols evolved, and as the products themselves were progressively improved.

University of Toronto Nobelpharma Replica Study

Investigators at the University of Toronto conducted a replica study¹⁴ to verify the results of the University of Goteborg trial. This is important, because the ADA requires an independent replica study to grant its acceptance.

Type of Study. Like the University of Goteborg trial, the University of Toronto replica trial was a serial study.

Study Population. Twenty-six subjects, ranging in age from 20 to 69 years, comprised the study population.

Treatment Procedure. Implant insertion was conducted according to the protocols established in the University of Goteborg trial. Four to six threaded titanium cylinder root form implants were submerged in the mandible of each patient, between the mental foramina. The implants were allowed to heal afunctionally for 4 to 6 months. During the healing period, approximately half of the patients wore their dentures, and the other half did not. The denture wearers had the tissue surface of their dentures generously relieved, and tissue conditioners were used and frequently changed.

At the end of the healing period, abutments were attached. Restoration was performed approximately 2 weeks after abutment attachment.

A silver-palladium, type III alloy was cast directly to the gold alloy cylinders that were screwed onto the titanium abutments for restoration. Early fracturing of the can-

tilevered portion of the bridges necessitated that type IV alloy be used instead. In 24 of the 26 patients a complete denture opposed the implant-supported bridge.

Evaluation of the prosthesis and tissue response to implantation was first conducted 1 to 3 months after prosthodontic restoration, and then annually thereafter.

Results

Success/Survival Rates. The University of Toronto replica study reported success rates, not survival rates. Success rates of both the implants and the prostheses were evaluated.

Success of an implant was regarded as osteointegration, regardless of whether the implants were in function. Thus, the success criteria used in this study cannot be equated with survival rates. “Sleepers,” implants that osteointegrated but could not be used because of lack of prosthodontic parallelism, were considered neither successes nor failures in the calculation of success rates (Table 8-6).

It was also reported that 25 of the 26 patients (96%) experienced continuous fixed-bridge function.

Bone Height. Periapical radiographic examination was first conducted at the time of abutment attachment, and then annually thereafter to evaluate changes in peri-implant bone height. Implants that were evaluated to be 20 degrees or more off perpendicular to the angle of the radiograph were not used for bone height measurement. Bone loss measurements were converted to metric units using the relative scale of the implant threading. Bone loss in the first year after abutment attachment averaged 1.6 mm, and thereafter averaged 0.13 mm annually. No significant differences were noted between bone loss at year 1 and year 3, or between the mesial and distal surfaces of the implants (Table 8-7).

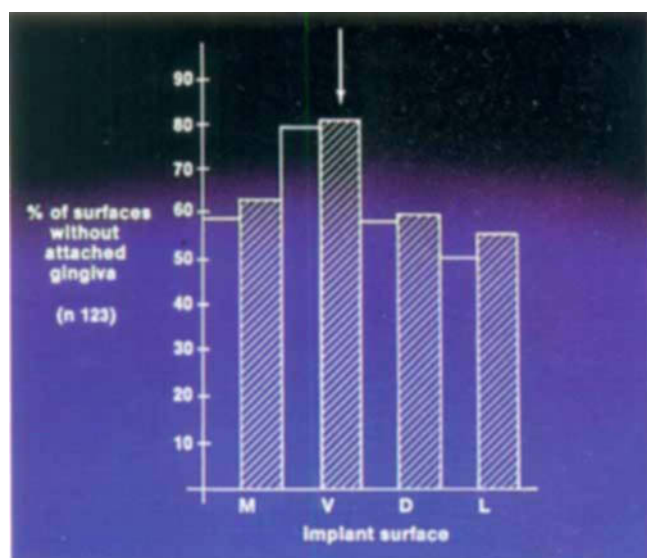


FIG. 8-9 ■ Percentage of surfaces with unattached gingiva around fixtures in University of Toronto study. M, mesial; V, vestibular; D, distal; L, lingual. (From Cox JF, Zarb GA: *Int J Oral Maxillofac Implants* 2:91, 1987.)

TABLE 8-8 UNIVERSITY OF TORONTO REPLICA STUDY IMPLANT SURVIVAL RATES

Arch	Number of Implants Inserted	Failures	Survivals
Maxilla	12	0	12
Mandible	139	25	114
TOTAL	151	25 (16.6%)	126 (83.4%)

Peri-Implant Tissues. Each surface of the implant was assessed to determine the extent of keratinized mucosa present at the end of the second and third years of observation. Unattached gingiva ranged from approximately 50% at year 2 on the lingual to a high value of approximately 80% at year 3 on the vestibular (Fig. 8-9). On each surface, the unattached gingiva index was observed to increase between years 2 and 3.

Both the plaque and gingival health indices were observed to be comparable with those for teeth, although the validity of using the gingival index to evaluate the implant was questioned because of the difficulty of applying it to peri-implant sites.

Each surface of the implant was measured using light probing force to determine pocket depth. Pocket depths were recorded to the nearest 0.5 mm. The mean pocket depth at year 2 was 3.6 mm, and at year 3 was 3.9 mm, with a range from 0 to 10 mm. Eighty percent had pocket depths of 3 mm or deeper, 53% had pocket depths of 4 mm or deeper, 34% 5 mm or deeper, and 14% 6 mm or deeper.

Mobility. Implant mobility was assessed by placing the implant abutment between the metal handles of two mirrors and exerting a heavy rocking force. If movement was detected clinically, the implant was considered a failure because of lack of osseointegration. Thus, all successfully osseointegrated implants showed no detectable clinical movement. It was also noted that mobility was almost al-

ways accompanied by the observation of a radiolucent area on the radiograph.

Analysis. Some of the results data in the University of Toronto replica study are worth further examination. The first is the exclusion of sleepers from consideration in deriving the success rates. Sleepers are implants that are presumably osseointegrated but were inserted at an angle such that they could not be used to support the prosthesis.

Following publication of this trial, the ADA requested that investigators consider sleepers to be failures, because the patient underwent a surgical procedure that did not provide the intended benefit.¹⁵

Inclusion of sleepers as failures in the results data is required to convert the success rates reported for this trial into survival rates. Table 8-8 shows survival rates with sleepers counted as failures.

Twenty-five of the 26 patients (96%) were reported to experience continuous fixed-bridge function. Of the 26 bridges fabricated, however, 12 developed fractures in the cantilevered portion of the prosthesis within the first few months of function. As a result, new frameworks were designed with an increased cross-sectional area of metal at the junction with the cantilevered regions, and the silver-palladium alloy was changed to one with higher yield and tensile strengths. After the bridges were replaced, no further fractures were noted. In addition, two of the gold alloy screws used to retain the bridge to the abutment fractured.

TABLE 8-9 UNIVERSITY OF TORONTO REPLICA STUDY PROSTHESIS SURVIVAL RATES

Number of Prostheses	Number of Fractured Prostheses	Number of Fractured Screws	Number of Unsupported Prostheses	Total Complications	Survival Rate
26	12 (46.2%)	2 (7.7%)	1 (3.8%)	15	46.2% to 57.7%

When they were replaced, they did not seat firmly, and the fracture of the original screws was suspected to have resulted from frameworks that were not completely passive. Therefore, these prostheses were remade.

It was not noted whether the one patient who switched to an overdenture after losing three implants on one side experienced a prosthesis fracture, or if the patients who experienced screw fracture also experienced prosthesis fracture. Therefore, to give the possible range, Table 8-9 shows prosthesis survival data assuming that these prosthetic complications completely overlapped, and again assuming that no overlap occurred.

Finally, it should be noted that the preimplantation bone loss caused by ramping to achieve sufficient ridge width that was unreported in the University of Goteborg trial also was unreported in the University of Toronto replica trial, as well as the bone loss from the point on the implant flush with the ridge crest at the time of implantation to the first thread. Thus, to determine how much total bone loss occurred during the procedure, 2 mm must be added for preimplantation ramping and 1.62 mm must be added to account for the distance to the first thread during the healing phase before abutment attachment, comprising a total of 3.62 mm of bone loss that can be added to all measurements.

Innova Endopore System

The reports included herein on the Innova Endopore System were chosen for reasons different from the Goteborg and Toronto research. The Endopore system was chosen for use in the posterior partial edentulism teaching case presented in this book, and therefore the research that demonstrates the safety and efficacy of this system requires special consideration.

The research conducted on a specific system does not necessarily apply to other systems of the same modality. In the case of the Innova Endopore system, the diffusion-bonded microsphere interface represents a meaningful departure from conventional screw- or cylinder-type root form implants.¹⁶ Interface area is increased to the extent that the implants need only be approximately two thirds the depth of conventional root forms. This translates into a broader range of mainstream clinical applicability and the ability to insert the implant at an angle closer to ideal for prosthodontic parallelism, which simplifies restorative protocols. For these reasons the Innova Endopore system was

included in this book. It substantially broadens the range of mainstream applications of the root form modality, especially in posterior arches in cases of partial edentulism, as in the teaching case.

Because of the fundamental differences in the interface and implant depth, one may not simply extrapolate that reports published on conventional root forms are 100% relevant to the Innova Endopore system.

Global Multi-Center Innova Endopore Study

Type of Study. The Global Multi-Center Innova Endopore Study¹⁷ represents a wide-scale collation of eight separate studies that used different protocols. These studies were conducted at the University of Toronto in Canada; Nihon University in Japan; a private clinic in Sydney, Australia; and by the U.S. Study Group, composed of the University of Kentucky, the Dental Implant Institute, and the Midwest Implant Institute. These studies had different objectives, protocols, and follow-up periods.

Success/Survival Rates. Table 8-10 shows the success data obtained in the multi-center study. Of the total of 1352 implants followed, approximately one third were placed in the maxilla and two thirds in the mandible. Table 8-11 shows a breakdown of success rates center by center in the maxilla and mandible.

It is worth noting that success rates are reported in this collation, rather than survival rates. Success is defined as “not having failed.” Therefore, these data include implants that have not yet been restored. Nonetheless, most of these data represent restored implants. It is interesting to note that the success rates for the Innova Endopore system have been observed to be slightly higher in the maxilla than in the mandible, contrary to popular wisdom that implants tend to succeed more readily in the mandible because of a higher quality of dense bone.

The 20 failures noted by the U.S. Study Group are broken down in Table 8-12.

The broad scope of the Global Multi-Center shows a comforting abundance of clinical usage, and the time frame of 2 to 8 years yields useful data regarding short-, intermediate-, and long-term implant function.

University of Tübingen Friadent Frialit-2 Study

Like the Global Multi-Center Endopore study, the University of Tübingen (Germany) study is presented here not because of its historic impact on the perception of the root form modality but because it firmly establishes the safety

TABLE 8-10 GLOBAL MULTI-CENTER ENDOPORE SUCCESS DATA

Study Center	Protocol	Number of Patients	Number of Implants	Years Post-function	Successful Implants	Success Rate (%)
University of Toronto	Mandibular overdenture	52	156	8	146	93.6
	Maxillary crown and bridge	48	148	2	147	99.3
	Posterior mandible	24	44	2	44	100
	Maxillary single tooth	20	20	2	20	100
Nihon University	Mandibular crown and bridge	42	78	3	75	96.2
Sydney, Australia	Partially edentulous	48	127	3	122	96.1
U.S. Study Group	Mandibular overdenture	94	281	5	264	94.0
	Partially edentulous	229	498	4	478	96.0
TOTALS		557	1352	2-8	1296	95.9

TABLE 8-11 GLOBAL MULTI-CENTER ENDOPORE STUDY SUCCESS DATA BY ARCH

Study Center	Protocol	Implants in Maxilla	Implants in Mandible	Successful Implants	Success Rate (%)
University of Toronto	Mandibular overdenture	—	156	146	93.6
	Maxillary crown and bridge	148	—	147	99.3
	Posterior mandible	—	44	44	100
	Maxillary single tooth	20	—	20	100
Nihon University	Mandibular crown and bridge	—	78	75	96.2
Sydney, Australia	Partially edentulous	75	—	70	93.3
		—	52	52	100
U.S. Study Group		210	—	202	96.2
		—	569	540	94.9
Total Maxilla		453	—	439	96.9
Total Mandible		—	899	857	95.3
Total Insertions		453	899	1296	95.9

TABLE 8-12 FAILURES IN U.S. STUDY GROUP OF GLOBAL MULTI-CENTER ENDOPORE STUDY

Causal Factor	Total Number of Failures	Prefunction	Incidence Rate (%)			
			0-12 mo	12-24 mo	25-36 mo	>36 mo
Not integrated	8	1.0	0.6			
Occlusal load by preexisting denture	5	1.0				
Contraindicated patient	2	0.4				
Occlusal mechanical overload/hyperfunction	3		0.4		0.2	
Postoperative infection	2		0.4			
Total incidence	4.0	2.4	1.4		0.2	

TABLE 8-13 INDICATIONS FOR TREATMENT IN UNIVERSITY OF TÜBINGEN STUDY

Indication	Number of Implants	Percentage of Implants
Single-tooth replacement	290	42
Posterior edentulism	164	24
Total edentulism	158	22
Interdental edentulism	84	12

TABLE 8-14 TIMING OF INSERTIONS IN UNIVERSITY OF TÜBINGEN STUDY

Timing	Number of Implants	Percentage of Implants
Immediate (within 1 wk of extraction)	86	12
Reossification phase (within 9 mo)	164	24
Late (after 9 mo)	446	64

TABLE 8-15 DEGREE OF RESORPTION OF PREIMPLANTATION RIDGES IN UNIVERSITY OF TÜBINGEN STUDY

Resorption Grade*	Percentage of Implants
A	19
B	49
C	26
D	5
E	1

*For an explanation of the resorption grades, see Lekholm U, Zarb GA: Patient selection and preparation. In Brånemark PI, Zarb GA, Albrektsson T, editors: *Tissue integrated prostheses: osseointegration in clinical dentistry*, Chicago, 1985, Quintessence.

TABLE 8-16 INTRAOPERATIVE BONE QUALITY IN UNIVERSITY OF TÜBINGEN STUDY

Bone Quality*	Percentage of Implants
1	8
2	42
3	43
4	7

*For an explanation of the bone quality index, see Lekholm U, Zarb GA: Patient selection and preparation. In Brånemark PI, Zarb GA, Albrektsson T, editors: *Tissue integrated prostheses: osseointegration in clinical dentistry*, Chicago, 1985, Quintessence.

and efficacy of the Friadent Frialit-2 system used in this book for the single-tooth replacement teaching case.

Type of Study. The University of Tübingen study was a wide-scale serial study conducted between 1990 and 1995.¹⁸ Like the Göteborg study, the investigators studied the efficacy of an implant they had developed themselves, so the study was not independent. A control group was not used because comparing results between patients who underwent the procedure and patients who remained edentulous (or who underwent a conventional procedure) was not part of the study objective. Therefore, randomization was not a factor. The data are longitudinal.

Study Population. The University of Tübingen research began with a 15-year investigation of the Frialit-1 implant, in which 1352 implants were placed in 1059 patients. Based on the findings of this preliminary study, the Frialit-1 implant was redesigned to counteract drawbacks related to resistance to fracture of the aluminum oxide ceramic implant body used originally. The successor Frialit-2 implant, made of commercially pure (CP) titanium, was investigated in a study conducted between 1990 and 1995. During this time, 696 Frialit-2 implants were placed in 376 patients. Implants were of varying diameters and depths according to the needs of the patient's anatomy.

The indications for implant treatment are shown in Table 8-13. The timing of implant placement was considered in the study, because the stepped feature of the Frialit-2 implant body was designed specifically to accommodate insertion into immediate extraction sites. Timing of insertion is broken down in Table 8-14. Intraoperatively, the degree of resorption of the ridge designated for implantation was assessed using the classification of Lekholm and Zarb¹⁹ (Table 8-15). Bone quality was also assessed intraoperatively according to the classification of Lekholm and Zarb¹⁹ (Table 8-16).

Results. Dental auxiliary staff recorded recall data, which were subjected to computer processing and analysis.

Success/Survival Rates. Of the 376 patients enrolled in the study, 9 with a total of 10 implants were lost to follow-up. Nineteen implants failed during the observation period, yielding a 97% survival rate. Most failures occurred before prosthodontic restoration. The mean time in situ of failed implants was 26 weeks, ranging from 1 to 93 weeks (Table 8-17).

Single-tooth replacement implants (290) had a 2.41% failure rate during the follow-up period, whereas implants used for interdental spans, posterior edentulism, or total edentulism (406) had a 2.95% failure rate. The failure rate of 86 implants inserted into immediate extraction sites was 1.16%, of 164 implants placed during the reossification stage was 0.60%, and of 446 implants classified as late placements was 3.81%.

Of the 7 single-tooth implants that failed, 5 were placed at least 9 months after extraction. Of these, four had not yet been restored.

Bone Height. The portion of the implant that was endosseous by design but was not in contact with bone at the time of insertion was defined as a coronal bone defect, and any increase in this defect was measured as peri-implant

TABLE 8-17 ANALYSIS OF FAILURES IN UNIVERSITY OF TÜBINGEN STUDY

Failure Number	Time in Situ (yr)	Indication	Timing	Cause
1	0.95	Single-tooth	Late	Prosthetic technique
2	0.13	Single-tooth	Late	Peri-implantitis
3	0.16	Posterior	Late	Peri-implantitis
4	0.24	Single-tooth	Late	Peri-implantitis
5	0.13	Total	Late	Peri-implantitis
6	0.13	Total	Late	Unknown
7	1.76	Single-tooth	Immediate	Peri-implantitis
8	1.79	Single-tooth	Reossification	Peri-implantitis
9	0.31	Total	Late	Insertion technique
10	0.38	Posterior	Late	Fibrous encapsulation
11	0	Total	Late	Insertion technique
12	0.59	Total	Late	Prosthetic technique
13	0.29	Posterior	Late	Peri-implantitis
14	0.63	Single-tooth	Late	Fibrous encapsulation
15	0.65	Posterior	Late	Fibrous encapsulation
16	0.65	Posterior	Late	Fibrous encapsulation
17	0.29	Posterior	Late	Fibrous encapsulation
18	0.25	Total	Late	Fibrous encapsulation
19	0.38	Single-tooth	Late	Fibrous encapsulation

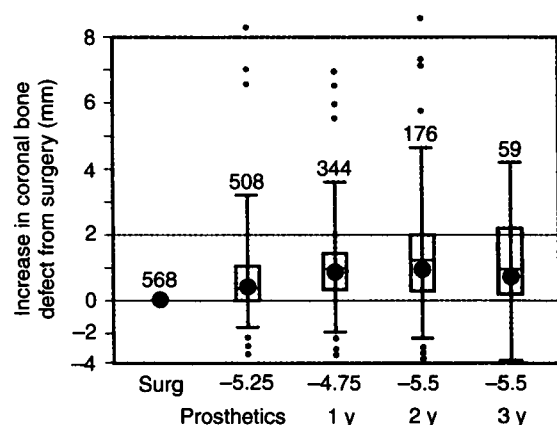


FIG. 8-10 ■ Progression of coronal bone loss as mean of mesial and distal radiographic measurements in University of Tübingen study. Number of implants noted above box plots; small dots and numbers beneath them designate outliers. (From Gomez-Roman G et al: *Int J Oral Maxillofac Implants* 12:3, 1997.)

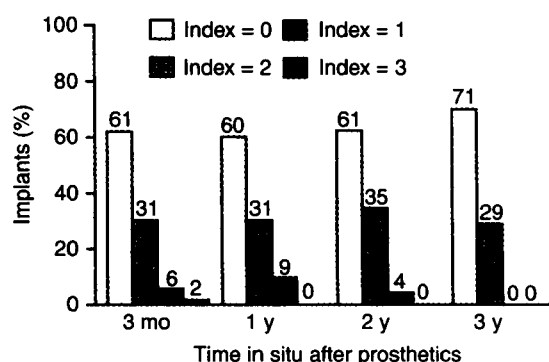


FIG. 8-11 ■ Plaque index (REF) in percentages of implants at various follow-up intervals in University of Tübingen study. (From Gomez-Roman G et al: *Int J Oral Maxillofac Implants* 12:3, 1997.)

bone loss.²⁰ No significant differences were observed between distal and mesial measurements of bone loss. At the time of prosthodontic restoration, the **median** increase in coronal bone defects was 0.5 mm. At the 1-year recall period the increase was 1.0 mm, and no further increase in bone loss was observed at the 2-year and 3-year follow-up intervals (Fig. 8-10).

Peri-Implant Tissues. Plaque index scores assessed at 3 months, 1 year, 2 years, and 3 years postoperatively according to the index of Silness and Löe²¹ showed a trend toward progressively improving oral hygiene (Fig. 8-11).

Gingival index scores assessed at the same intervals according to the index of Löe and Silness²² showed either absence of or minimal inflammation (Fig. 8-12).

Peri-implant probing depths were represented as a box plot of the means of the mesial, distal, facial, and lingual values (Fig. 8-13). The median of the mean obtained from the four probing sites remained between 2 and 3 mm at all recall intervals.

Mobility. Periotest measurements had an overall median of -2 (Fig. 8-14). An increase in Periotest values was observed 3 months after insertion as a result of bone

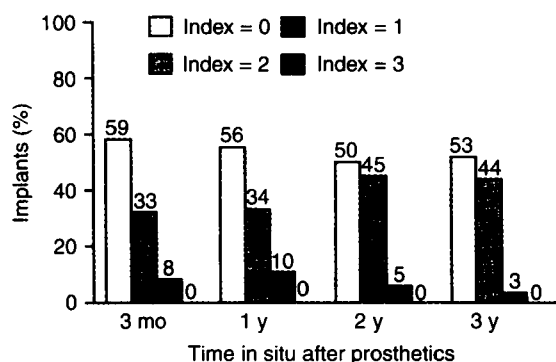


FIG. 8-12 ■ Gingival index (REF) in percentages of implants at recall in University of Tübingen study. (From Gomez-Roman G et al: *Int J Oral Maxillofac Implants* 12:3, 1997.)

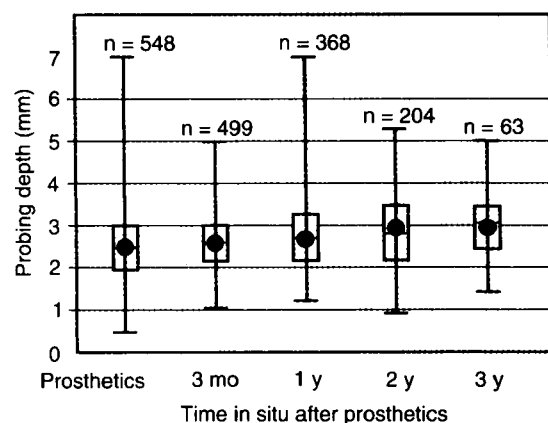


FIG. 8-13 ■ Peri-implant probing depth (mean of four sites) at follow-up in University of Tübingen study. Medians designated by circles within the boxes, means as lines within the boxes. (From Gomez-Roman G et al: *Int J Oral Maxillofac Implants* 12:3, 1997.)

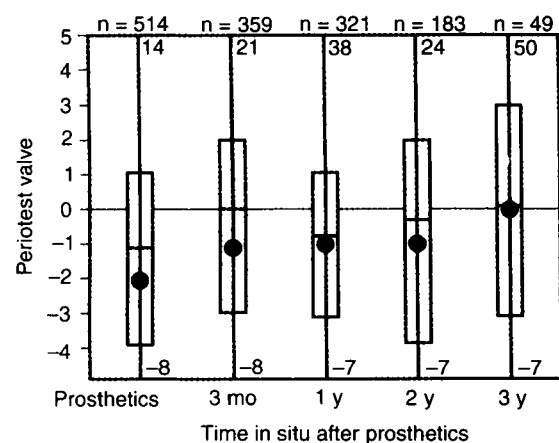


FIG. 8-14 ■ Periotest data at follow-up in University of Tübingen study. Numbers adjacent to box plots designate outliers; circles within box plots designate medians, and lines within box plots designate means. (From Gomez-Roman G et al: *Int J Oral Maxillofac Implants* 12:3, 1997.)

remodeling at the implant interface, as is commonly observed with other implant systems.

SEMINAL PLATE/BLADE FORM INVESTIGATIONS

Veterans Administration Plate/Blade Form Study

The Veterans Administration (VA) study²³ conducted on the Oratronics Weiss Osteo-Loc Standard One-Stage Plate/Blade Form implant system may be the finest study ever conducted in our discipline. Together with its replica study, funded by the National Institutes of Health (NIH) and conducted at Harvard University,²⁴ the VA study was responsible for achieving ADA acceptance of the Oratronics Weiss Osteo-Loc Standard One-Stage Plate/Blade Form Implant System. A full-time VA biostatistician worked closely with the study chairman to design the protocol and conduct the study. Begun in 1977, the study was conducted at five VA hospitals using identical protocols.

Unlike the seminal root form investigations, which followed the course of consecutively implanted root implants to evaluate their success/survival and the conditions of their peri-implant sites, the VA plate/blade form study had a comparative objective. If a partially edentulous patient is not treated using implants, only one other restorative option exists—the use of partial removable dentures. Thus, the primary objective of the study was to compare endosteal plate/blade form implants acting with natural cobutments to support a fixed unilateral prosthesis with bilateral distal-base extension removable partial dentures. The study compared treatment failure rates, incidence of abutment tooth or implant loss, amount of bone loss, mobility, pocket depth, gingival inflammation, hypersensitivity, plaque index and caries incidence of abutment and nonabutment teeth, rate of residual ridge resorption, number and types of complications, change in masticatory performance, overall patient satisfaction, and cost of initial and follow-up treatment.^{12,25,26}

Type of Study. The VA study was prospective, randomized, independent, controlled, and longitudinal.

Study Population. A total of 272 patients, ranging in age from 25 to 77 years, were entered into the study. This sample size was chosen such that a 20% difference in failure rate and/or 50% difference in reduction of mesial or distal crestal bone height around abutment teeth in a period of 5 years would be detected with at least 95% probability.

To ensure that the control and experimental groups would be comparable, age, edentulous classification, and number of abutment teeth were used as variables to stratify the patients. The 3 variables provided 10 stratification categories for random assignment into the experimental and control groups (Table 8-18). According to this stratification, the patients were randomly separated into experimental and control groups as shown in Table 8-19.

The final number of patients at the baseline interval examination was 232. For various reasons, 22 patients were

TABLE 8-18 STRATIFICATION CATEGORIES FOR RANDOMIZATION IN VETERANS ADMINISTRATION STUDY

Age (yr)	Edentulous Classification	Number of Abutment Teeth	Stratification Category
25-54	Class I	2	01
		3	02
		4	03
	Class II	1	04
55 and older	Class I	2	05
		3	06
		4	07
	Class II	1	08
		2	09
		2	10

TABLE 8-19 RANDOMIZATION OF GROUP ASSIGNMENT IN VETERANS ADMINISTRATION STUDY

VA Center	Treatment		Total
	Unimplanted Removable	Implanted Fixed	
1	20	27	47
2	28	26	54
3	34	31	65
4	19	22	41
5	33	32	65
TOTAL	134	138	272

TABLE 8-20 CHARACTERISTICS OF OPPOSING DENTITION IN VETERANS ADMINISTRATION STUDY

	Commencement (0 wk)		Baseline (16 wk)	
	Unimplanted Removable	Implanted Fixed	Unimplanted Removable	Implanted Fixed
Edentulous without dentures	0.7	2.2	0.0	0.0
Complete dentures	17.9	14.5	21.2	15.8
Removable partial denture	12.7	13.0	37.3	28.9
Natural dentition or fixed prosthesis	68.7	70.3	41.5	55.3

terminated from the study before implant surgery or placement of their partial dentures. Because of buccal or lingual bone plate perforation, implants were not placed in four patients. These instances were considered surgical failures. Six patients experienced early implant failures before baseline. Two patients with implants died before insertion of the fixed prosthesis. Six patients (four unimplanted with removable dentures and two with implants and fixed prostheses) withdrew from the study after completion of the treatment but before the baseline interval examination. Six of the 10 patients with surgical or early failures underwent implant surgery a second time and were reentered in the study as a separate group.

Table 8-20 shows the characteristics of the opposing dentition of the patients. Increases in the percentage of patients with complete and removable partial dentures and the decrease in patients with maxillary natural dentition and fixed partial dentures resulted from the insertion of new removable prostheses as required by the individual treatment plan.

To ensure that the results data were meaningful, valid baseline data were obtained carefully. Baselines were established for periodontal health of remaining maxillary teeth, mandibular teeth, and primary abutment teeth for the unimplanted removable and implanted fixed groups, for gingival recession, and for bone height.

TABLE 8-21 IMMEDIATE POSTTREATMENT PERIODONTAL INDICES IN VETERANS ADMINISTRATION STUDY

	Maxillary				Mandibular				Abutment			
	Unimplanted Removable		Implanted Fixed		Unimplanted Removable		Implanted Fixed		Unimplanted Removable		Implanted Fixed	
Condition	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Plaque	0.43*	0.67	0.49*	0.66	0.52*	0.77	0.54*	0.74	0.47*	0.84	0.62*	0.76
Calculus	0.44*	0.66	0.42*	0.65	0.40*	0.62	0.54*	0.69	0.54*	0.76	0.60*	0.75
Gingival inflammation	0.37*	0.86	0.42	0.70	0.18*	0.77	0.43*	0.85	0.04	0.99	0.30*	1.05
Sulcus depth (mm)	0.19*	0.44	0.16*	0.42	0.10*	0.45	0.12*	0.43	0.02	0.55	0.05	0.49
Mobility	0.06	0.35	0.11*	0.36	0.08*	0.37	0.15*	0.36	0.10*	0.39	0.11*	0.41

*Values represent a significant improvement compared with baseline.
SD, Standard deviation.

Immediate posttreatment effects were evaluated for both groups by subtracting the periodontal index scores at baseline from those at the commencement of the study. Except for sulcus depth of abutment teeth, significant improvement was noted in the implanted fixed prosthesis group for each index. In the unimplanted removable denture group, gingival inflammation, sulcus depth of abutment teeth, and mobility of maxillary teeth failed to show significant improvements. None of the mean differences showed statistical significance between the two groups. Mean values that represent a significant improvement compared with baseline are marked with asterisks in Table 8-21.

Treatment Procedure. All treatment was performed at five VA medical centers. The participating investigators were not experienced implantologists. To learn the treatment protocol, they attended a 2-day continuing education lecture followed by a demonstration. Each investigator then performed the insertion procedure on one patient under the direct supervision of the instructor. After returning to their respective medical centers, the investigators placed at least five plate/blade form implants in non-study patients. Radiographs of these patients were submitted to the study chairman to verify that the procedure had been performed correctly. In four of the VA medical centers, one investigator performed the surgical procedure and a second investigator performed the prosthodontic procedure (the team approach). In the fifth medical center, a single investigator performed all procedures (the solo approach). An independent examiner not involved in performing either the surgical or prosthodontic treatments collated the results data.

The removable partial dentures used in the study were of two designs: one using an I-bar clasp, mesial rest, and proximal guide plane; and the other using a circumferential clasp, distal rest, and indirect retainer.

In each patient in the experimental group, a high-speed contra-angle handpiece with an XL or XXL bur was used

to prepare the osteotomy with external coolant supplemented by saline irrigation via a syringe. Sutures were removed after 6 to 8 days. In the event that on reflection of the soft tissue any complication was noted, such as excessive bleeding, potential impingement on the neurovascular bundle, or perforation of the buccal or lingual plate during osteotomy preparation, the implant was not placed and was counted as a technical failure. A minimum of 12 weeks was allowed to pass before reimplantation in such cases, at which time the patient was reentered into the study and the previous technical failure data were retained. Each implant was splinted to the natural co-abutment(s) 6 weeks after insertion. The final fixed prosthesis was cemented within 10 to 14 weeks after implant insertion.

Unless a canine was the only available mandibular abutment tooth, splinted double abutments were used on the distal extension side of all mandibular fixed prostheses and removable partial dentures.

Each patient underwent orofacial examination; dental examination including periodontal, caries, and prosthodontic evaluations; SMA-12 laboratory testing; panoramic radiographs; full intraoral radiographs; lateral and oblique cephalometric radiographs; intraoral 35-mm color slides; diagnostic casts; masticatory performance tests; food selection questionnaire; 1-week dietary chart; and a patient evaluation questionnaire. Such comprehensive dental examinations were performed before commencement of the study (except cephalometric radiographs), 16 weeks after placement of an implant or insertion of a removable partial denture (except SMA-12 tests and radiographs of teeth that did not require crowns or cervical restorations), and thereafter at 6 months, 18 months, 36 months, and 60 months.

Patient follow-up every 6 months included routine dental examination, oral prophylaxis, plaque control instructions, and any needed treatment for at least 5 years. At each visit, a standardized periapical radiograph was taken of the

TABLE 8-22 SUCCESS RATES OF REMOVABLE PARTIAL DENTURES IN UNIMPLANTED CONTROL GROUP IN VETERANS ADMINISTRATION STUDY

Months After Insertion	Successful at Beginning of Interval	Failed During Interval	Withdrawal Despite Success	% Success at End of Interval	95% Confidence Interval
0-12	122	12	3	90.0	84.7-95.3
12-24	107	11	5	80.5	73.2-87.8
24-36	91	3	2	77.8	70.4-85.2
36-48	86	2	5	76.0	68.2-83.8
48-60	79	2	6	74.0	66.0-82.0

TABLE 8-23 SUCCESS RATES OF FIXED PROSTHESIS IN IMPLANTED GROUP IN VETERANS ADMINISTRATION STUDY

Months After Insertion	Successful at Beginning of Interval	Failed During Interval	Withdrawal Despite Success	% Success at End of Interval	95% Confidence Interval
0-12	128	12	6	90.4	85.3-95.5
12-24	110	2	5	88.7	83.2-94.2
24-36	103	2	4	87.0	81.1-92.9
36-48	97	2	1	85.2	78.9-91.5
48-60	94	1	6	84.2	77.7-90.7

implant and abutment teeth to determine changes in bone height. Oral examinations were performed to evaluate teeth for caries and restorations, periodontium, removable denture, and supporting tissues. **Ordinal scales** were used to score plaque, mobility, calculus, and gingival inflammation. The plaque and mobility indices were the same used for patient screening before the study began.

Results

Success/Survival Rates. The presence of any of the following was considered failure of an implant: total range of movement in excess of 3 mm; 30% vertical bone loss around an implant; need to remove an implant because of unmanageable infection, pain, paresthesia, or other reasons; or loss of an abutment tooth. Implants that for any reason were not inserted during surgery were counted as surgical failures. Any implant that required removal before restoration was considered an early failure.

The presence of any of the following was considered failure of a removable partial denture: patient inability to tolerate the prosthesis, patient not using the prosthesis for mastication, and loss of an abutment tooth.

Table 8-22 shows the treatment success rates of the removable partial dentures in the unimplanted group according to these criteria. Table 8-23 shows the success data for the patients in the fixed prosthesis supported by an implant and natural co-abutment(s) treatment group. These data include those patients with surgical or early failures and two patients who died before the fixed prosthesis

could be placed. These latter two cases were also counted as failures.

The success rate of implanted fixed prosthesis patients at 60 months was 10.2% higher than the 60-month success rate of unimplanted removable prosthesis patients, but this difference was not statistically significant. When the Kennedy class I patients were considered separately, the class I implanted patients showed a statistically nonsignificant success rate 5.2% higher than the unimplanted patients. In contrast, the success rate of class II implanted patients at 60 months was a statistically significant 17.9% higher than that of unimplanted patients.

Not including surgical and early failures or the two patients who died, the data for the implanted patients who received fixed prostheses are given in Table 8-24. When these success rates are compared with those of the unimplanted removable prosthesis group, the 60-month success rate of the implanted fixed prosthesis group is a significant 17.5% higher.

The implanted fixed prosthesis group of class I patients showed an 8.9% higher success rate, and the class II patients a 21.3% higher success rate than the corresponding unimplanted removable denture subgroups. The class II difference was statistically significant.

The status of 250 patients at 60 months after receiving removable partial dentures (RPDs) or implants and fixed prostheses (FPDs) is shown in Table 8-25. Twenty-one patients with successful RPDs and 22 with successful FPDs

TABLE 8-24 SUCCESS RATES OF FIXED PROSTHESES NOT INCLUDING EARLY FAILURES, SURGICAL FAILURES, OR PATIENT DEATH IN IMPLANTED GROUP IN VETERANS ADMINISTRATION STUDY

Months After Insertion	Successful at Beginning of Interval	Failed During Interval	Withdrawal Despite Success	% Success at End of Interval	95% Confidence Interval
0-12	116	2	4	98.2	95.5-100.0
12-24	110	2	5	96.4	92.9-99.9
24-36	103	2	4	94.5	90.2-98.8
36-48	97	2	1	92.5	87.6-97.4
48-60	94	1	6	91.5	86.2-96.8

TABLE 8-25 TREATMENT SUCCESS RATES AT 60 MONTHS IN VETERANS ADMINISTRATION STUDY

	Number of Patients						Success Rate %					
	Withdrawn		Successes		Failures		Total		Low		High	
	RPD	FPD	RPD	FPD	RPD	FPD	RPD	FPD	RPD	FPD	RPD	FPD
Class I	10	6	23	25	9	12	42	43	55	58	79	72
Class II	11	16	48	62	21	7	80	85	60	73	74	92
TOTAL	21	22	71	87	30	19	122	128	58	68	75	85

RPD, Removable partial dentures; FPD, fixed prostheses.

TABLE 8-26 IMPLANT SUCCESS RATES IN VETERANS ADMINISTRATION STUDY

Months After Insertion	Successful at Beginning of Interval	Failed During Interval	Withdrawal Despite Success	% Success at End of Interval	95% Confidence Interval
0-12	170	15	8	91.0	86.7-95.3
12-24	147	4	7	88.4	83.5-93.3
24-36	136	4	4	85.8	80.3-91.3
36-48	128	2	1	84.4	78.7-90.1
48-60	125	1	8	83.7	78.0-89.4

withdrew from the study before the 60-month interval for various reasons, including patient death, and their ultimate treatment outcome was unknown. According to the preestablished success criteria, a total of 71 RPD and 87 FPD treatments were known to be successful, and 30 RPD and 19 FPD treatments were known to be failures. Assuming that all withdrawals were failures gives the lowest possible success rate, and assuming that all withdrawals were successes gives the highest possible success rate. The true success rate falls somewhere between and can be extrapolated by excluding the withdrawn patients. These data are subdivided into Kennedy class I and II subgroups. The difference between the success rates of the two treatment modalities was more pronounced for patients with Kennedy class II than for those with class I edentulism. The lowest

possible success rates both for class I and II patients and the highest possible success rate for class II patients treated with FPDs were greater than those for patients treated with RPDs.

Success rates based on life table analysis of the surgical implant attempts are shown in Table 8-26.

Excluding the 12 surgical and early implant failures and three intact implants in two patients who died before receiving the FPD, the implant success rate for the remaining 155 implants was 98% at 12 months and 90.2% at 60 months.

Bone Height. Periapical radiographs at various intervals were available for 102 implants with single posts and 46 implants with double posts. Each radiograph was evaluated by three judges to determine the presence and extent

TABLE 8-27 ORDINAL SCALE BONE LOSS EVALUATIONS IN VETERANS ADMINISTRATION STUDY

Score	Baseline				60 mo			
	Examiner			Consensus	Examiner			Consensus
	1	2	3		1	2	3	
1	45.0	54.5	40.6	45.0	19.6	18.3	12.6	16.4
2	27.7	12.0	25.0	23.6	13.2	9.9	12.0	10.0
3	11.5	13.6	19.8	14.1	15.3	12.0	16.2	18.0
4	6.8	7.3	7.3	7.9	8.5	18.3	22.5	14.3
5	6.3	9.9	5.7	6.3	29.1	21.5	21.5	27.5
6	1.6	2.1	1.6	2.6	7.4	11.0	8.4	7.4
7	1.0	0.5	0.0	0.5	4.2	6.3	4.7	3.7
8	0.0	0.0	0.0	0.0	0.0	1.6	0.5	0.5
9	0.0	0.0	0.0	0.0	2.6	1.0	1.6	2.1

of bone loss around each implant post. A score between one and nine was assigned to each post according to the consensus of the three judges. A score of one was described as representing the most desirable implant-bone interface, with bone covering and in intimate contact with most of the neck. A score of two was described as representing bone either covering less than half the neck, or not in as intimate contact with the neck as those with a score of one. Scores of three or higher were described as representing discernible cupping or evidence of bone loss around the neck (Table 8-27).

The most bone loss was noted to occur in the first 12 months, after which the bone-implant interface became relatively stable. No change in the bone-implant interface was evident around 29.6% of the posts, slight change in 25.4%, moderate change in 15.9%, marked change in 27%, and severe change in 2.1% over the 60-month period.

Of the six implants evaluated to have severe radiographic bone loss, three had already been judged as failures, and the other three were still functioning in place symptom-free, continuing through 95 months.

Peri-Implant Tissues and Mobility. As with the baseline data, the mandibular, maxillary, and abutment teeth were considered separately. Both the unimplanted RPD group and the implanted FPD group tended to show statistically nonsignificant declines in most of the indices. Furthermore, none of the clinical data between the RPD and FPD groups showed significant differences.

Changes in the periodontal health of the implants were also evaluated. The calculus, gingival inflammation, and mean sulcus depth scores showed significant increases, but the mobility score showed a significant decrease. At 60 months, 63.9% of the implant posts exhibited no detectable mobility, compared with 47.5% at baseline. The deepest sulcus depth was found to be 3 mm or less around 68 implants, 4 mm around 30 implants, 5 mm around 16 implants, and 6 mm or more around 15 implants.

Complications. In the implanted group, seven patients experienced buccal or lingual cortical bone perforation during surgery, including one patient with perforations on both sides. Implants were not placed in four perforated sites. One patient with an implant in a perforated site died of natural causes before restoration. The remaining three implants in perforated sites were declared failures, two because of infection and one even though it continued to function in place at 72 months. Eight implants were removed because of pain and/or mobility before restoration. Noteworthy complications of pain, infection, or paresthesia were noted in another 16 patients during the 5-year period after restoration. The infection in one patient was related to an endodontic problem of the abutment tooth and not related to the implant. Seven implants in 5 of these 16 patients were declared failures. Four of the implants with persistent infection were removed, and a fifth patient who refused removal had the implant functioning in place without discomfort at the end of the 60-month period. Eight patients required repair of their prostheses.

In the removable partial denture group, five patients experienced abutment tooth loss because of excessive bone loss. In addition, 23 patients required rebasing, 11 required the fabrication of new partial dentures because of broken or distorted frameworks or lost dentures, and three required both a rebase and the fabrication of a new removable partial denture during the 60-month period.

Analysis. To conform bone loss values for comparative purposes, it is necessary to convert the ordinal index scores noted in the VA study into metric measurements. This can be done because of the existence of known fixed reference points (e.g., the dimensions of the implant neck). Because the angles, distances, and exposures of the radiographs were standardized, accurate measurements of bone height can readily be derived.

The ordinal scores of the VA study were converted into metric measurements using only the point of most bone loss around any given post. The descriptions given for each

TABLE 8-28 ORDINAL/METRIC CONVERSION
TABLE FOR BONE LOSS IN VETERANS
ADMINISTRATION STUDY

Rating Scale Score	Bone Height Loss (mm)	Percentage of Implants (60 mo)
1	0.1-0.5	29.6
2	1.1-2.0	25.4
3	0.5-2.0	15.9
4	1.5-2.0	27.0
5	2.0	
6	2.0-3.5	
7	3.5	2.1
8	4.5	
9	>4.5	

classification in the nine-point scale were interpreted, and the corresponding radiographs were visually analyzed and measured. Using this procedure, the conversion in Table 8-28 was derived.

Thus, according to this conversion system, rating scores of one to four represented bone loss of 2 mm or less. A total of 97.9% of the implants lost 2 mm of bone or less at 5 years.

It is worth noting that five of the abutment teeth used for the support of removable partial dentures were lost because of the excessive and nonvertical forces to which they are subjected, whereas none of the abutment teeth used as co-support with an implant abutment under a fixed prosthesis were lost in the 5 years of the study.

To derive survival rates, one must take the total number of implant insertion attempts in this study and subtract the number of subject withdrawals so that they will not be considered as either successes or failures, to obtain the pool of subjects with data that may be considered. Of the 170 implant surgeries attempted, a total of 28 implants were lost to follow-up, leaving 142 implants that could be considered for survival data. Of these, only four were removed. Thus 138 of the 142 implants were in position and functioning for their intended purpose at the 60-month follow-up interval, yielding a survival rate of 97.3%.

Harvard/NIH Plate/Blade Form Replica Study

The Harvard/NIH replica study²⁵ was submitted along with the VA clinical trial to obtain the "Accepted" designation from the ADA for the Oratronics Weiss Osteo-Loc Standard One-Stage plate/blade form system.

Type of Study. The Harvard/NIH trial was an independent, controlled, longitudinal, prospective study.

Study Population. Thirty-four patients ranging in age from 21 to 60 years were treated with complete dentures opposing bilateral four-unit fixed bridges. One bridge was supported distally by a plate/blade form implant, representing the experimental treatment, and the other was a

cantilevered bridge unsupported distally, representing the control treatment.

Treatment Procedure. The treatment procedure for the blade-supported bridge basically followed that used in the VA study.

Results

Success/Survival Data. Among the 34 patients, two experienced treatment failure on the implant side because of excessive mobility and pain, and their implants were removed. A third patient's implant was evaluated as a failure because of mobility but remained in position and in function at the 36-month measurement interval. Interestingly, the degree of mobility of this implant fell well within the success criteria in the previous VA study. The three evaluated failures occurred at 8 months, 18 months, and 33 months. Thus, the success rate for the implant side was 97% at 1 year, 94% at 2 years, and 91% at 3 years.

On the cantilevered bridge side, three patients experienced treatment failure as a result of excessive mobility, bone loss, or bicuspid fracture during the first 36 months of follow-up. These failures occurred at 18 months, 21 months, and 33 months. Thus, the success rates for the cantilevered bridges were 100% at 1 year, 94% at 2 years, and 91% at 3 years.

In addition, two consecutive implants failed in one patient and one in another before baseline, which was established at the time of bridge placement. These implants were replaced before baseline and followed. With regard to the bridges, one failed on the implant side at 24 months, and one failed on the cantilevered side at 15 months. The bridges were replaced.

Of the 34 patients originally enrolled in the study, 32 had success data at the 36-month interval on at least one treatment side. Seventeen patients had 36-month data for both treatment sides. Thirty posterior ridges treated using implant-supported bridges and 29 posterior ridges treated with cantilevered bridges had 36-month follow-up data.

Bone Height. Radiographic analysis of mesial and distal bone/root ratios demonstrates no significant difference between the implant and cantilever abutment teeth. The distal bone/root ratios were in the 0.93 to 0.94 range for both the cuspid and the bicuspid at baseline and at 36 months (Table 8-29). The mesial bone/root ratios were in the 0.91 to 0.92 range for both the cuspid and the bicuspid at baseline and at 36 months (Table 8-30).

Radiographs of each of the 24 implant patients in the study are shown in Fig. 8-15. Serial radiographs of two selected cases over 48 months are shown in Fig. 8-16.

Two patterns of bone loss were observed around the neck and shoulder of implants in function. One pattern appeared to reach a plateau within 6 months and was exhibited by 14 patients (Fig. 8-17). The other pattern, exhibited by 18 patients, showed that bone loss plateaued at approximately 12 months (Fig. 8-18).

Peri-Implant Tissues. Gingival health was observed around the bicuspid and cuspid on both treatment sides, and around the implants. Periodontal health improved significantly at the implant cuspid and implant bicuspid, and

TABLE 8-29 DISTAL BONE/ROOT RATIOS IN HARVARD/NIH REPLICA STUDY

	Distal Bone/Root Ratio		
	Bridge Placement	Month 36	Change
Cantilever for cuspid	0.926	0.939	-0.014
Implant for cuspid	0.936	0.930	0.004
Difference for cuspid	-0.005	0.009	0.020
Cantilever for bicuspid	0.938	0.932	0.008
Implant for bicuspid	0.932	0.938	-0.005
Difference for bicuspid	0.006	-0.002	-0.007

TABLE 8-30 MESIAL BONE/ROOT RATIOS IN HARVARD/NIH STUDY

	Mesial Bone/Root Ratio		
	Bridge Placement	Month 36	Change
Cantilever for cuspid	0.909	0.915	-0.008
Implant for cuspid	0.906	0.923	-0.013
Difference for cuspid	0.002	-0.006	-0.001
Cantilever for bicuspid	0.922	0.911	0.011
Implant for bicuspid	0.912	0.919	-0.002
Difference for bicuspid	0.009	-0.005	-0.009

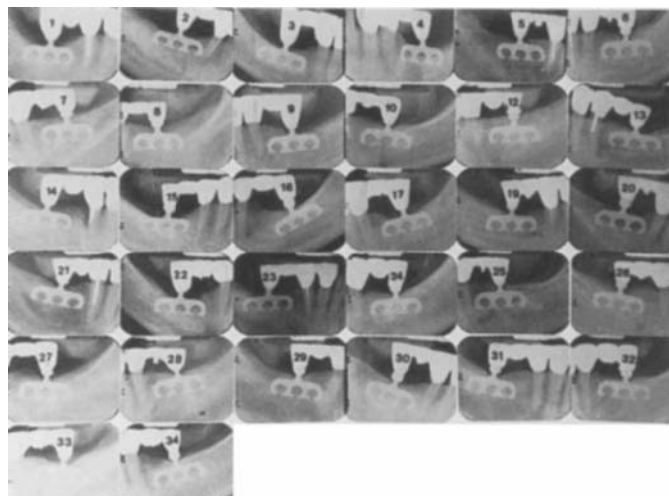


FIG. 8-15 ■ Representative radiographs of patients in the NIH/Harvard plate/blade form study.

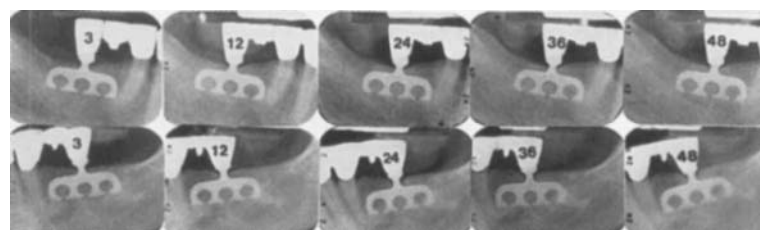
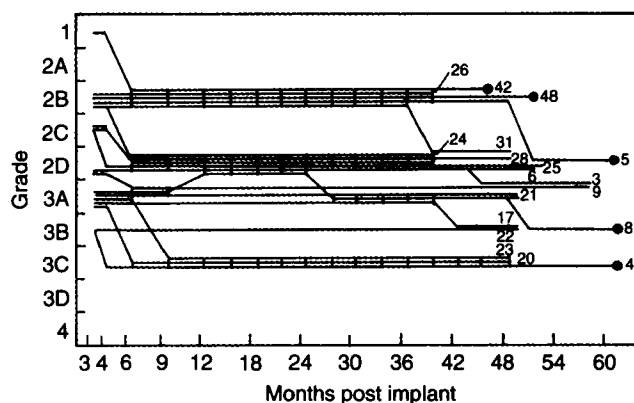
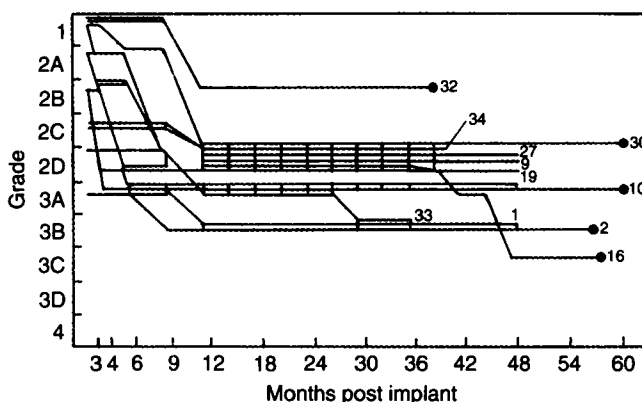


FIG. 8-16 ■ Serial radiographs of two patients over 48 months in the NIH/Harvard plate/blade form study.

FIG. 8-17 ■ Six-month plateau bone pattern in Harvard/NIH plate/blade form study.**FIG. 8-18 ■** Twelve-month plateau bone pattern in Harvard/NIH plate/blade form study.**TABLE 8-31 ■ MOBILITY IN HARVARD/NIH STUDY**

Abutment	Bridge Placement	Month 36	Change
Cantilever for cuspid	0.093	0.088	-0.004
Implant for cuspid	0.088	0.083	-0.006
Difference for cuspid	0.004	-0.001	0.004
Cantilever for bicuspid	0.124	0.188	0.063*
Implant for bicuspid	0.162	0.126	-0.035
Difference for bicuspid	-0.038	0.070*	0.116*
Implant 200 g	0.369	0.351	-0.021
Implant 300 g	0.519	0.455	-0.088

*Values represent significant differences.

peri-implant health improved significantly at the implant abutment.

At all sites, the average loss of gingival attachment between baseline and 36 months was less than 0.8 mm. For the cuspid, loss of attachment was somewhat greater on the implant side than on the cantilever side. Loss of gingival attachment for the bicuspid showed essentially no difference between treatment sides. For the implant, there was a nonsignificant increase in attachment at the buccal and lingual sites over the 36-month follow-up period.

Mobility. The cuspid and bicuspids on both treatment sides, as well as the implant, were analyzed for mobility by periodontometry. Values that represent significant differences in Table 8-31 are marked with asterisks.

Analysis of mean abutment mobility demonstrated a significantly greater change between baseline and 36 months

for the cantilever bicuspid than for the implant bicuspid. Average mobility significantly increased for the cantilever from 0.124 mm at baseline to 0.188 mm at 36 months. For the implant bicuspid, mobility decreased from 0.162 mm to 0.126 mm.

For both the cantilever cuspid and the implant cuspid, no statistically significant change in mobility was observed between baseline and 36 months. Average mobility was 0.08 to 0.09 mm for both abutments at both times.

No statistically significant change was observed in average implant mobility at 200 g between baseline (0.359 mm) and 36 months (0.351 mm). Thus, although mobility for the implant was greater than that for the abutments, the lack of change appeared to be consistent with successful implant function. Subjective patient comments supported this interpretation.

Complications. At 36 months, few of the 32 patients reported complications. One patient exhibited 1.5 cm of numbness of the vermilion border of the lip. This condition was not incapacitating, and the patient stated that she “would have the procedure again.” Three patients required deep curettage of their implants, and three others required deep curettage of the cantilever abutment teeth.

SEMINAL SUBPERIOSTEAL IMPLANT INVESTIGATIONS

More than the endosteal abutment-providing modalities, the subperiosteal implant modality relies on a long-term preponderance of use to establish its safety and efficacy. Designing a proper prospective study is challenging for this modality, and even analyzing serial studies is difficult, because each implant is custom-made and therefore unique. There are many variables. However, in light of preponderance of use, retrospective studies take on special significance, insofar as they validate that subperiosteal implants are safe and effective for their intended purpose.

A specific challenge of reporting the results of using subperiosteal implants is that the advantages of this implant modality make it uniquely suitable for patients who have a history of tooth loss, other difficulties with their natural dentition, and severe ridge resorption. Such patients show a trend that may suggest that treatment of any kind is less likely to succeed than in patients with a general history of good oral health. Also, patients who have alveolar ridge resorption sufficient for the use of a subperiosteal implant tend to be older, and therefore long-term data are more difficult to obtain.

University of Southern California Prospective Survival Study

The University of Southern California (USC) Prospective Survival Study reported on subperiosteal implants placed at the USC School of Dentistry Advanced Prosthodontic Clinic over 14 years.²⁷ It is notable as being one of the few prospective subperiosteal studies on record.

Study Population. The study included 81 patients who received mandibular subperiosteal implants. Patient age ranged from 39 to 77 years.

Treatment Procedure. Dentists who had received instruction in advanced education programs in prosthodontics and oral and maxillofacial surgery at USC administered all treatment. A commercial laboratory fabricated the mandibular subperiosteal implant framework and superstructure attachment. All implant frameworks were cast in a cobalt-chromium alloy. The first 20 implants were fabricated with four vertical posts, and the remainder had integral bilateral posterior mesostructure bars.

Patients were examined 6 months after placement of the implants. Thereafter, patients were recalled annually. Clinical examinations evaluated paresthesia, the condition of the tissue around the abutment posts, reaction to strong vertical forces, oral hygiene, and available space beneath

the abutment bars. Panoramic radiographic analysis was also performed. Subjective evaluation was solicited from the patients. Telephone interviews were conducted 6 months after each clinical examination.

Some patients who relocated could not be followed up clinically. Attempts were made to contact these patients with annual questionnaires in addition to the annual telephone contact. The questionnaire asked patients to describe the current status of their implants; specific problem areas; use of dentures; pain or discomfort during eating; chewing efficiency; comfort compared with their prior conventional dentures; frequency of swelling, inflammation, or infection; frequency of antibiotic use; paresthesia; and personal opinions regarding the value of the treatment they had received.

At the annual clinical examination, adjustments were made if required and any encountered problems were treated appropriately. Criteria for removal of mandibular subperiosteal implants included pain, chronic or repeated episodes of acute inflammation, and paresthesia. When it was observed, paresthesia developed after the initial healing period and resulted from settling of the framework until it impinged on the inferior alveolar nerve.

Results

Success/Survival Rates. At the 10-year follow-up interval, 63 patients could be evaluated (in consideration of their time of entry into the study). Patients who died or were lost to follow-up before 10 years were not included in the survival table. Nine patients who underwent partial removal of their subperiosteal implants were considered failures by the investigators, although the implant survived and the remaining parts of the framework provided years of additional service. Of these nine patients, five underwent bilateral partial posterior abutment removal, and four underwent unilateral abutment removal. Survival data over time were calculated for these patients, showing retained functioning implants with partial removals as failures and as survivals (Fig. 8-19).

Bone Height. Because the subperiosteal implant modality is not endosteal, analysis of changes in bone height is not strictly relevant. The only circumstance in which bone height is important in subperiosteal implant dentistry is if resorption continues from under the implant after it is seated. If this is the case, then the case was misdiagnosed, and an endosteal implant might have been used. This occurrence was not reported in the USC study.

Soft Tissues. Chronic infection was the most frequent soft-tissue complication treated. Eight patients received free autografts of palatal tissue around chronically inflamed abutments. To reduce the potential for inflammation, five patients received presurgical skin or palatal grafts at the abutment sites to provide keratinized mucosa around the transmucosal abutment posts. Frequent and/or severe inflammation isolated to a posterior abutment was treated by partial removal of the implant distal to the anterior abutment.

Complications. After initial healing of the implant, a range of complications of varying intensity was encountered. Patients who had complications were given options

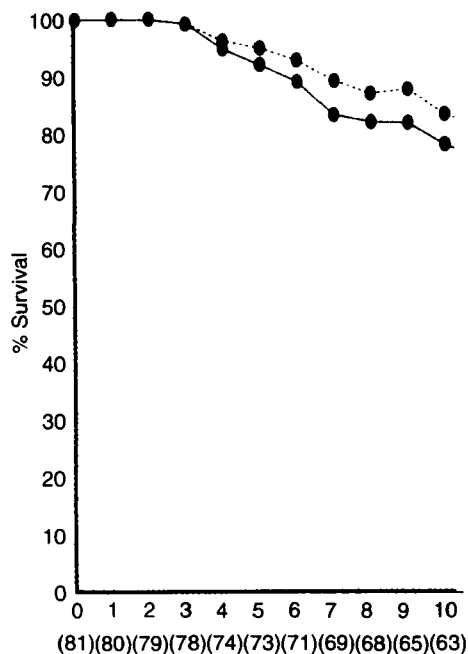


FIG. 8-19 ■ Survival rates of subperiosteal implants in patients followed up for 10 years without framework alterations for maintenance (solid line) and with framework alterations for maintenance (dotted line) in USC study. (From Yanase RT et al: J Prosthet Dent 71:369, 1994.)

for further treatment. Inflammation, infection, and swelling of the tissues surrounding the implant posts were the most common complaints. Patients received antibiotic therapy when severe episodic swelling and inflammatory changes developed. Pain, settling of the implant, and paresthesia were often related to inflammatory episodes. Inflammation itself was not an absolute indication for removal, but a combination of inflammation, pain, and post-healing paresthesia was an indication for removal.

Analysis. Including partially functional implants, the survival rate was 94%. Not including partially functioning implants, the survival rate was 79%. These rates indicate that the subperiosteal implant modality is safe and effective for its intended purpose of providing abutments for prosthetic dentistry in cases of severe alveolar ridge resorption.

Although long-term survival of subperiosteal implants is comparable with that of endosteal implant modalities, a higher incidence of soft-tissue complications is expected. More diligent maintenance is required both on the part of the practitioner and the patient. In most cases, such complications are reversible.

University of Missouri–Kansas City Research

Researchers at the University of Missouri–Kansas City (UMKC) have been reporting the use of subperiosteal implants since 1955, including an article in 1983 that re-

TABLE 8-32 TEN-YEAR STATUS OF SUBPERIOSTEAL IMPLANT PATIENTS TREATED BETWEEN 1955 AND 1975 IN UMKC STUDY

Patient Number	Longevity (Yr)	Status at 10 Yr
1	12	Implant replaced
2	16	Functional
3	14	Functional
4	2	Unrelated patient death
5	13	Functional
6	12	Functional
7	11	Functional
8	2	Implant removed
9	9	Functional
10	8	Implant removed for replacement
11	7	Functional

ported the outcomes of all subperiosteal mandibular implants restored at UMKC between 1955 and 1975.²⁸ Currently, the third in the series of reports is being written, and the authors would like to express their appreciation to Dr. Dorsey Moore for supplying us with the data related to subperiosteal implants placed at UMKC from 1982 through the present.

Study Population. Of the 25 patients treated with subperiosteal implants at UMKC between 1955 and 1975, 10 were available for examination at the time of the 1983 report (Table 8-32). Table 8-33 shows the subperiosteal implants placed at UMKC dental school from 1982 through 1998. Although the follow-up period possible for these patients ranges from 0 to 16 years, this represents an impressive body of data for ongoing and future evaluation of the subperiosteal implant modality. All of the implants listed in Table 8-33 were in a state of survival though the “date last seen,” demonstrating that as the design and placement techniques have become more refined over the years, the prognosis of the treatment has improved over time.

Results

Success/Survival Rates. The survival of the implants placed at UMKC was presented previously in the section discussing study population. Other criteria for determining success were evaluated both by the patient and the practitioner for the implants placed between 1955 and 1975. Similar data are being compiled for the post-1982 implants, but is not yet available. The subjective data are only reported for those patients whose implants were still in function at the time of evaluation.

Table 8-34 shows practitioner evaluations of the various success criteria. The letter *D* indicates that the factor

TABLE 8-33 SUBPERIOSTEAL IMPLANT PATIENTS TREATED SINCE 1982 IN UMKC STUDY

Patient Number	Date Placed	Gender/Age at Placement	Date Last Seen
1	2/23/82	F/51	9/97
2	3/30/83	F/68	5/98
3	5/19/83	F/62	9/97
4	11/1/84	F/68	8/97
5	7/10/86	F/61	9/97
6	6/23/88	F/50	2/92
7	10/11/89	F/67	5/97
8	2/28/90	F/80	12/97
9	9/26/90	M/64	4/97
10	10/3/90	M/76	8/97
11	11/21/90	F/53	6/97
12	1/29/91	F/75	8/97
13	4/18/91	F/63	9/96
14	8/27/91	F/75	8/97
15	5/6/92	F/54	10/97
16	10/22/92	M/74	8/97
17	3/3/93	F/62	6/98
18	8/4/93	F/60	3/97
19	9/22/93	M/50	4/97
20	4/6/94	F/63	11/96
21	3/29/95	F/51	8/97
22	5/31/95	F/56	10/96
23	7/2/95	M/62	10/97
24	1/10/96	F/70	10/97
25	7/3/96	F/53	3/97
26	7/31/96	F/65	8/97
27	1/29/97	M/61	8/97
28	8/1/97	F/47	11/97
29	11/11/97	F/70	11/97
30	3/18/98	F/54	3/99
31	6/10/98	M/71	New
32	6/24/98	F/50	New

TABLE 8-34 PRACTITIONER EVALUATIONS OF SUCCESS CRITERIA OF PATIENTS TREATED BETWEEN 1955 AND 1975 IN UMKC STUDY

Patient Number	Mobility	Bone Loss	Gingival Inflammation	Present Infection	Paresthesia or Anesthesia
1	N/A				
2	D	D	D	D	D
3	F	D	F	F	F
4	N/A				
5	F	D	F	F	D
6	F	F	F	F	F
7	F	F	F	F	F
8	N/A				
9	F	D	F	F	D
10	N/A				
11	F	D	F	F	F

The letter *D* indicates that the factor was considered a deterrent to success; the letter *F* indicates that the factor was considered favorable for success.

TABLE 8-35 PATIENT EVALUATIONS OF SUCCESS CRITERIA OF PATIENTS TREATED BETWEEN 1955 AND 1975 IN UMKC STUDY

Patient Number	Mobility	Bone Loss	Gingival Inflammation	Present Infection	Paresthesia or Anesthesia
1	N/A				
2	F	F	F	D	F
3	F	F	F	D	F
4	N/A				
5	F	F	F	D	F
6	F	F	F	F	F
7	F	F	F	D	F
8	N/A				
9	F	F	F	D	F
10	N/A				
11	F	F	F	F	F

The letter *D* indicates that the factor was considered a deterrent to success; the letter *F* indicates that the factor was considered favorable for success.

was considered a deterrent to success; the letter *F* indicates that the factor was considered favorable for success. Table 8-35 shows patient evaluations of the same factors.

CONCLUSION

How long is long enough for an implant to survive? Certainly, no implant treatment using any modality is guaranteed to last for a specific number of years, or is permanent. That an implant can survive for 20 years or more may not even be relevant for our oldest patients. If a patient can be offered 10, or even 5, years of enhanced function, implant dentistry can provide a great service and improvement in quality of life.

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9 Considerations Common to Mainstream Dental Implant Treatment Protocols

This chapter discusses those steps in the preinsertion, postinsertion, aftercare, and maintenance procedures that are common to the protocols of all of the mainstream applications of the abutment-providing modalities covered in this book—root forms, plate/blade forms, and unilateral subperiosteal implants. When studying or treating a case, this chapter should be read in tandem with the chapter in the book that is specifically related to the modality and treatment selected for the case at hand. The protocols for each modality contain some common steps—for example, one must incise along the ridge crest in the same manner and according to the same principles whether treatment is performed using root forms, plate/blade forms, or a subperiosteal implant. However, the extent of the incision is unique to each modality. Therefore, any specific considerations related to common steps are covered separately in the step-by-step procedure chapters that follow.

Common treatment steps are found in the preinsertion and postinsertion phases. There is little commonality in the insertion protocols, which vary not only modality by modality but often system by system within the same modality. It is also interesting to note that most complications that can occur during treatment are generally not unique to any modality.

Awareness of the similarities among the treatment protocols of each modality reassures the practitioner that they are all technique-permissive and follow the same general course of events. However, the differences between the treatment protocols are important to understand. The protocols of each modality are unique with regard to osteotomy preparation when applicable, implant insertion or placement, location, required healing time, and restorative requirements. Applying the unique requirements or considerations of one modality to another is a common error that can lead to complications.

Note that in the following sections that relate to surgical procedure, what the hand is doing and what the mind is thinking are described for each step. Descriptions of what the hand is doing appear as regular text. Descriptions of what the mind is thinking appear as italicized text set against a yellow screen. It is important to understand not only what one must do, but also what one's focus of thought should be at the time, to perform these surgical procedures properly.

PRESURGICAL CONSIDERATIONS **Identify and Quantify the Volume** **of Available Bone**

Identify and quantify available bone in cases using either endosteal implant modality. Follow the principles laid out in Chapter 3 to identify the borders and landmarks in the portion of the ridge that will receive the implants. Remember that the seated implant should ideally not be closer than 1 mm, and preferably 2 mm, from each landmark or border. Thus, one can outline the “usable” available bone on the radiograph to visualize the length and depth of available bone into which the implant(s) can be inserted in endosteal implant cases (Fig. 9-1). Determine width according to the principles in Chapter 3, remembering that the thickness of the gingiva in the mandible is much thinner and more consistent than in the maxilla, in which the use of a ridge width gauge to penetrate to bone may be required to determine alveolar ridge thickness. Computerized axial tomography (CAT) scans and the like are not required to determine available bone volume in mainstream cases.

With available bone length and depth quantified, and width clinically confirmed to be within acceptable limits for the chosen modality, it is time to select the ideal im-

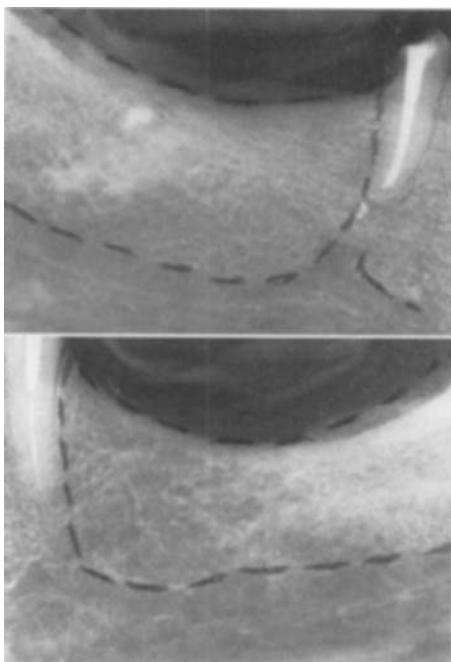


FIG. 9-1 ■ Available bone outlined on periapical radiographs.

plant configuration if an endosteal system is used. When treating with a subperiosteal implant, ensure that residual alveolar bone is not excessive by reconfirming all previous measurements. These procedures are covered in the step-by-step treatment chapters that follow for each abutment-providing implant modality.

Preoperative Medication for the Insertion Visit

There is a range of opinion regarding the prophylactic use of antibiotics before and following the implant insertion visit. Although the implant insertion procedure in mainstream cases is less traumatic and less invasive than, for example, the removal of a third molar, antibiotic coverage is recommended. Although the main blood supply to the tissues covering the alveolar ridge generally courses parallel to its crest, vessels will be severed along the incision line. Preoperative administration of an antibiotic allows it to flow past the planned incision line to serve areas that would otherwise be unprotected.¹ Because of frequent advances in medications, it is best to follow current published guidelines when prescribing preoperative antibiotics.

Administration of anti-edema medication is generally not required for mainstream cases. Trauma is minimal, and it is good policy to avoid the use of drugs when possible. If, based on a patient's history, there is reason to believe that edema may be greater than normal, a prescription for a corticosteroid dose pack (Medrol) provides patients with a handy kit with all required medication and instructions. Prescribe allowance for one refill in case excessive edema continues postoperatively. Another way

to control edema is to administer one infiltration of corticosteroid (Decadron 8 mg) at the time of administration of local anesthetic. This covers the patient for 2 days and may reduce immediate postoperative discomfort.²

The same policy applies to preoperative sedation. It should be avoided whenever possible. A caring touch of the hand and a few words expressing that one will be gentle throughout the procedure provides the best reassurance for the patient. Also, it is in the interest of patients that they be alert following treatment. Ideally, no one should be required to chaperone the patient home. In the absence of sedation, patients can drive, return to work, and otherwise leave the office as they would following a routine dental appointment for most other treatments. Patients who take prophylactic aspirin daily often are advised to discontinue such use for 3 weeks before treatment, to allow for normal clotting at the insertion visit.³

PREINSERTION CONSIDERATIONS

Confirm That Preoperative Medication Has Been Taken

In case the preoperative prophylactic antibiotic medication has not been taken, it is best to have antibiotics on hand for immediate administration when the patient arrives. If a patient on an aspirin regimen failed to discontinue its use, the insertion procedure may still be performed. Delayed clotting is sometimes observed in such cases.

Instrumentation Setup— The Armamentarium

Two sterile tray setups are suggested. The setup of the first tray, which is essentially the same for any abutment-providing implant modality and therefore is covered here, includes all instruments not directly involved with the implant during insertion. It should include a mirror, explorer, bone curette, bone file, tissue scissors, shaping and trimming rongeurs, needle holder, Noyes scalpel scissors, 3-0 atraumatic silk sutures, needle forceps, suture scissors, gauze squares, hemostatic agent, and a spatula (Fig. 9-2).

The setup of the second tray, which depends on the implant modality and system being used for the case at hand, holds the specialized instrumentation involved with implant insertion, as well as the implants and their components. This setup, customized for each implant system, is described in the step-by-step protocol chapters that follow. The loaded trays are placed side by side.

Sterilization is performed before surgery, as with all dental treatment instrumentation.

Preparation of the Operatory and Surgical Field

Infection is rare during the weeks following the insertion of dental implants. The surgical field may be prepared according to the regulated standards of surgical procedure



FIG. 9-2 ■ Selection of instruments used before and after implant insertion.

as accepted and used in practice today.^{4,5} Together with prophylactic antibiotic coverage, appropriate preparation of the surgical field protects against postoperative infection at or around the inserted implant. Most practitioners who insert dental implants in the United States and abroad do not have dedicated operatories. Thorough observance of standards of care and of government regulations (Occupational Safety and Health Administration [OSHA] and Centers for Disease Control and Prevention [CDC] guidelines) is required, as it is for removing an infected tooth or a third molar. Review of the clinical trials reported in Chapter 8 confirms the very low incidence of complications related to infection around healing dental implants.

Professional prophylaxis is recommended within 2 weeks before the insertion procedure, followed by careful home care.

Local Anesthetic, Promotion of Comfort, and Control of Bleeding

In mainstream cases, neither general anesthesia nor intravenous sedation is required. By definition, mainstream cases and the patients who present with them are ideal. Preoperative sedation is preferred over general anesthesia for patients who are unusually apprehensive.

In the mandible, an inferior alveolar block may be administered. Following the application of a topical anesthetic, one and often two carpules containing 1:100,000 vasoconstrictor are administered in the same manner as for a conventional molar removal. When lip and tongue symptoms appear, infiltrate additional local anesthetic into the fold in the planned osteotomy location(s). This will anesthetize any cervical nerve supply that may extend into the area and materially reinforce the block anesthe-

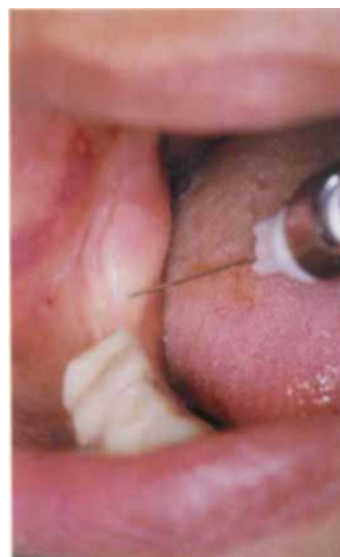


FIG. 9-3 ■ Administration of local anesthetic at ridge crest.

sia. Some practitioners forgo the block anesthesia and only infiltrate, as is routinely done in the maxilla. According to this option, infiltration is considered sufficient, and if during osteotomy drilling one approaches too closely to the nerve supply, the patient can respond to prevent complications. Proper implant selection to clear landmarks sufficiently is the best way to avoid paresthesia. Finally, a few drops of local anesthetic containing vasoconstrictor are deposited 5 mm apart along the projected incision line, to further ensure anesthesia and reduce bleeding at the time of incision, tissue reflection, and suturing (Fig. 9-3).

Preoperative Tissue Preparation

Before surgical intervention, the oral cavity is thoroughly inspected to locate and remove any residual food particles, followed by thorough lavage. One's preferred intraoral topical bacteriocidal agent is applied.⁶ Suction equipment is attached and tested, and the patient, practitioner, and dental assistant are positioned for comfort and ease of treatment.

Incision

Evaluate the Attached Gingiva. Identify and examine the band of attached gingiva along the ridge crest. Grasp the cheek and horizontally extend the unattached gingiva to reveal clearly its buccal extent. Digital manipulation reveals its lingual border.

Plan the Incision Line. With an indelible tissue marker, draw the extent of the incision line on attached gingiva (Fig. 9-4). If the band of attached gingiva is wide enough buccolingually, draw the incision line more toward the buccal. If the proximal border of a planned implant is within 5 mm



FIG. 9-4 ■ Mark or visualize the planned extent of the incision.



FIG. 9-5 ■ Incise through periosteum firmly against cortical bone.



FIG. 9-6 ■ Reverse scalpel for clean incision against natural abutment.

of the gingival cuff of an adjacent natural tooth, extend the line over the cuff up to the tooth.

Adequate access is a key to fine implant treatment. To ensure this, the incision will be longer mesio-distally than the length of bone required to receive the implant(s).

This ensures that unnecessary trauma and tissue tearing can be avoided during reflection of the tissue flaps, and that the practitioner will have clear access to the site. Because the blood supply courses mesio-distally along the planned incision line, relatively few vessels will be severed, and bleeding is easily controlled. Right-angle incisions into the vestibular unattached gingiva are not advised. Such incisions sever too much of the blood supply, resulting in excessive bleeding, edema, and postoperative pain.

Make the Incision. The incision is now made along the marked line. The scalpel is positioned distally and pressed through the tissue against the crest of bone, ensuring that the overlying periosteum is cleanly incised (Fig. 9-5). The incision is continued anteriorly. In the mandible, because the overlying tissue is usually 1 to 2 mm thick, the scalpel most often will press firmly against dense hard cortical bone at the ridge crest. In the maxilla, tissue thickness varies from patient to patient, and from area to area within the same patient. Overlying tissue typically ranges from 1 to 2 mm but can reach 10 mm or thicker. It usually is 1 to 2 mm thick anteriorly. The scalpel will press firmly against cortical bone, or sometimes against cancellous bone. Crestal bone in the maxilla is far more porous than the dense cortical bone encountered in the mandible. When approaching the distal of the gingival cuff around an adjacent tooth, lift the scalpel from the incision line, turn it around, and place its dull back edge against the distal surface of the tooth. Press crestally to cleanly incise through the tissue, and connect to the original incision line (Fig. 9-6).

The incision is made slowly and deliberately. Feel the blade's contact with the ridge crest and press firmly to ensure clean incision through the overlying periosteum. This facilitates tissue reflection and prevents undue trauma. There are no substantial vessels between the periosteum and the underlying bone. A second pass with the scalpel may be made, but it is more desirable to incise completely in the first pass. This reduces the number of tissue tags along the incision line and ridge crest.

Hemostasis. Check and control bleeding. Using damp gauze, apply direct pressure along the length of the incision line for a few moments. If minor bleeding persists, a few drops of local anesthetic containing vasoconstrictor inserted directly into the area usually suffices to ensure a clean field.

Control of bleeding is important because it permits better visualization of the surgical field, which in turn facilitates tissue reflection and the steps that follow. Good access and direct unobstructed vision of the operative field is essential. To achieve this, proper lighting and patient positioning are essential. The next consideration is the extent of the incision mesio-distally, to ensure that the field is totally visible and unobstructed following tissue reflection. In one's first few cases, having more visibility and access than necessary is better than having too little. With experience, it will be possible to reflect less tissue.

Tissue Reflection

Use of Periosteal Elevator. Use of the periosteal elevator is common to all abutment-providing modalities, but the extent of reflection varies.

Gently pass the periosteal elevator between the periosteum and bone, and reflect the gingival tissues. Reflect the lingual flap first. In the mandible and the buccal/labial of the maxilla, where the tissues are thinner, use a standard

periosteal elevator. For the thicker, tougher lingual flap of the maxilla, choose a heavy-duty elevator for reflection. Explore the incision line with the tip of the elevator until it passes between the periosteum and bone with ease.

The periosteum is composed of dense, tough tissue. When the elevator tip is passed cleanly between the periosteum and bone, problems are rare. There are no substantial vessels between the periosteum and bone. If, instead of passing under the periosteum, the elevator passes between the outer surface of the periosteum and the gingival crest, it will enter a connective tissue area replete with blood vessels and nerve supply. Increased bleeding, postoperative edema, and pain will result. Therefore, when a periosteal elevator is used, the eyes of the practitioner should be on the point at which the periosteum can actually be observed peeling away from the bone, to confirm that the elevator is in fact under the periosteum.

The next step is to reflect the buccal or labial flap. Use a standard elevator in both the mandible and the maxilla. In the maxilla, the standard elevator is used for the buccal or labial flap because it is more friable than its lingual counterpart. Complete reflection of the labial or buccal flap to its desired extent.

Carefully inspect at every point in this procedure to be sure of remaining under the periosteum. Slow, deliberate motions ensure accuracy, reduce over-reflection, and reduce postoperative edema. Generally, it is more difficult to reflect the tissue in the maxilla, because it is thicker and the bone is more porous, providing better anchorage for tissue inserts to fasten the periosteum to bone. With the flaps reflected, examine the exposed alveolar ridge for width, undercuts, imperfections, bony projections, and residual tissue tags. Radiographs cannot offer the accurate information that direct vision affords at this time. For the endosteal modalities, reevaluate the dimensions of the available bone, and for subperiosteal implants, confirm that the depth of reflection is adequate to expose sufficient basal bone for the planned procedure. Now is the time to change the treatment plan in favor of another configuration or even an alternative modality if the ridge width is insufficient.

Technique Options. The periosteal elevator can be used in three ways to complete the reflection. Try each one to determine which, for the case at hand, reflects tissue with the most control and ease. In using the periosteal elevator for the endosteal modalities, the depth of penetration is determined by the need to reflect only enough tissue for unobstructed vision, a clear operating field, and exposure of enough ridge for observation of its long axis and external anatomy. This helps avoid perforation of a cortical plate during osteotomy preparation. In the case of subperiosteal implants, reflection is performed to a depth sufficient to expose the basal bone upon which the main bearing struts will rest. Stop at the superior and lateral borders of the genial tubercle in the mandible, and fully expose the inferior border of the anterior nasal spine in the maxilla.

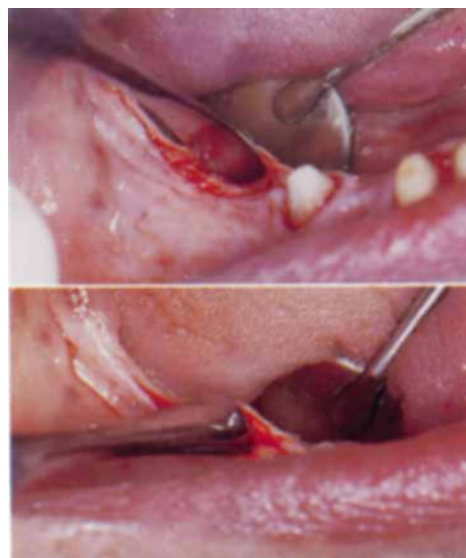


FIG. 9-7 ■ Periosteal elevation rotation option.

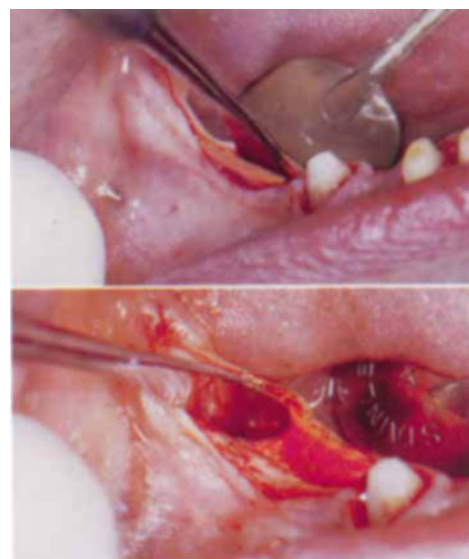


FIG. 9-8 ■ Periosteal elevation lifting option.

When reflecting for treatment with any modality, one option is to insert the elevator tip to the desired depth, and rotate it clockwise and then counterclockwise to lift the flap (Fig. 9-7). Insert it distally, and rotate until the flap is sufficiently reflected to its distal extent. Then move the elevator mesially, and repeat the rotations until the flap is sufficiently reflected to its mesial extent. Another option is to insert the tip of the elevator to its desired depth, hold it hard against cortical bone, and gently raise the handle vertically, thus elevating the tissue without tearing (Fig. 9-8). Move the elevator tip distally and then mesially, repeating the motion, until the flap is reflected to its distal and mesial extents. The final option is to insert the elevator tip to its desired depth, and move the instrument bodily along the incision line, mesially and then

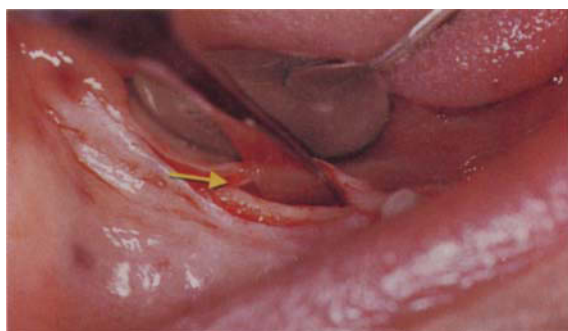


FIG. 9-9 ■ Periosteal elevation stripping option. Arrow shows periosteum lifting from bone.

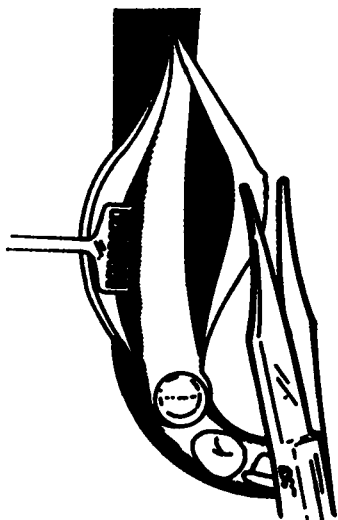


FIG. 9-10 ■ Trim to even edges of tissue flaps.

distally, stripping the periosteum from the bone (Fig. 9-9) until the flap is sufficiently reflected.

When reflecting for treatment using endosteal modalities, one must take the planned osteotomy into consideration. The osteotomy will be drilled within the confines of the labial and lingual cortical plates of bone, at an angle as close to the dictates of prosthodontic parallelism as possible, especially when splinting is planned. Therefore, reflect tissue until the slope of the lingual plate of the residual alveolar ridge can easily be observed. Generally, reflection to a depth of 10 to 15 mm is sufficient.

Trim Tissue Flap Edges

Examine the mesio-distal length of the incised edges of the buccal/labial and lingual flaps. If present, tissue tags and jagged edges are now conservatively trimmed using tissue scissors or Noyes scalpel scissors (Fig. 9-10). In cases of excess or flabby tissue, trim the edges of one or both flaps so they can coapt snugly over the ridge crest. Be sure to con-

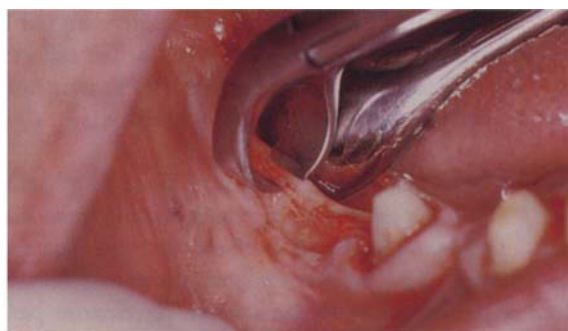


FIG. 9-11 ■ Rongeur removes bony projections and tissue tags.



FIG. 9-12 ■ Bone file gently smooths crestal areas after rongeur is used.

serve sufficient attached gingiva to encase as much of the pergingival area of each planned implant as possible.

Even, trimmed flap edges can coapt closely at suturing to promote rapid, predictable healing and reattachment of attached gingiva to the ridge crest.

Ridge Crest Cleansing and Alteration

Examine the crest of the residual alveolar ridge. If bony projections or tissue tags are present, use the end-cutting shaping and trimming rongeur to remove them (Fig. 9-11). Areas of unexpected residual soft tissues from previous periodontal or periapical conditions are curetted. A bone file is conservatively used to smooth crestal areas thus treated (Fig. 9-12).

The jaws of the end-cutting shaping and trimming rongeur are offset to facilitate use in proximity to natural teeth. Every effort is made to alter bone as little and as gently as possible.

INSERTION CONSIDERATIONS

The principles and protocols of insertion vary modality by modality, and system by system within each modality. These protocols are described in detail in the step-by-step

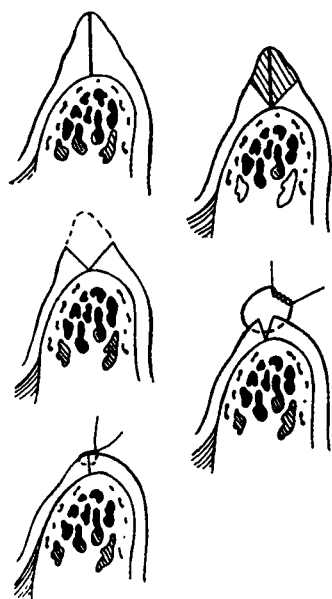


FIG. 9-13 ■ Remove excess tissue if necessary.

procedure chapters that follow for each type of mainstream treatment. The common consideration is that the specific protocol for the implant modality and system used for the case at hand must be followed with diligence. Many of the complications that arise in implant dentistry are the result of assuming that the insertion protocol of one modality or system is the same as that of another. This is an error that must be avoided.

POSTINSERTION CONSIDERATIONS

Gingival Flap Plastic Surgery

Remove Excess Tissue. The buccal and lingual gingival flaps are now coapted and examined. Occasionally the existence of excess tissue precludes the possibility of firm, neat closure when suturing.

Note whether the excess tissue, if any, is part of the buccal/labial flap, the lingual, or both, to determine where and how much trimming is indicated. Recall the width of the original attached gingival band. Ensure that if excess gingiva is trimmed along the flap edge, a band of at least 2 mm of attached gingiva remains to coapt around each abutment or healing collar.

Trim the excess tissue as required using serrated fine-tissue scissors. Again, coapt the flaps and make corrections as required (Fig. 9-13).

A good serrated tissue scissors holds the flap edges without slipping. A fine-tissue holder is also helpful, affording more precise control while cutting. Straight, even edges with no tissue tags or tears promote rapid healing by primary intention.

Decrease Flap Thickness. The tissue may be too thick, especially in the maxilla. Excessively thick tissue can

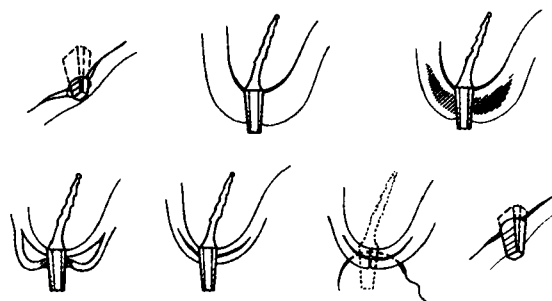


FIG. 9-14 ■ Reduce excess flap thickness.

cover too much of an abutment, create a pocket, or necessitate the use of a healing collar of excessive height if the semi-submerged healing protocol is followed. Reducing the height of excessively thick gingiva, in addition to avoiding these problems, can also increase interocclusal clearance and help enhance esthetics. With a scalpel, remove wedges of tissue from between the periosteum and the gingival crest as illustrated (Fig. 9-14).

Excessive thickness is the result of the presence of too much fibrous connective tissue. Removing tissue wedges from between the periosteum and gingival crest reduces the gingival flap thickness while retaining intact gingival epithelium at the crest and valuable periosteum against bone.

Reduce Flabby Tissue. Coapt the buccal and lingual flaps. The reduction of tissue thickness causes an excess of flabby tissue at the closure line, because the section with the gingival epithelium is longer than it needs to be after the wedge of tissue has been removed. Trim as previously described, coapt the flaps again, and inspect to see if closure will be neat and clean.



FIG. 9-15 ■ Semi-lunar tissue punch contours gingiva around abutment.

Now everything has been done to ensure that the tissue will be snug against the ridge, have a band of attached gingiva at the crest, and be appropriately contoured to promote sufficient exposure of the abutment for esthetics and cementation.

Correct Tissue Bunching

When suturing around a healing collar in the semi-submerged two-stage healing protocol or an abutment in the one-stage healing protocol, it often is noted that in coapting, the tissue tends to bunch. If not corrected, this bunching will preclude the formation of a cleansable, stable peri-implant sulcus at the pergingival site.

Note which flap, or if both of them, are responsible for the tissue bunching. Tissue will be removed from one or both flaps to form a semi-lunar arc that will coapt correctly around the abutment.

To properly excise this tissue, use a semi-lunar tissue punch. With an indelible pencil, mark the point on the targeted gingival flap that lines up with the center of the healing collar or abutment where bunching is observed when the tissue is coapted. Place the semi-lunar tissue punch, and remove an appropriately sized half-circle of tissue (Fig. 9-15). Reposition the edges of the flaps. Check for accuracy, and adjust if required (Fig. 9-16).

Every advantage has now been afforded the soft-tissue healing process. Snug, firm tissue and a fine pergingival cuff are promoted. Flush, suction, and inspect the entire field of operation for absolute cleanliness.

Radiographic Check

Periapical radiographs of the seated implants and surrounding tissue are taken, developed, and evaluated (Fig. 9-17). This will not interfere with early healing.⁷



FIG. 9-16 ■ Properly contoured tissue around abutment before suturing.

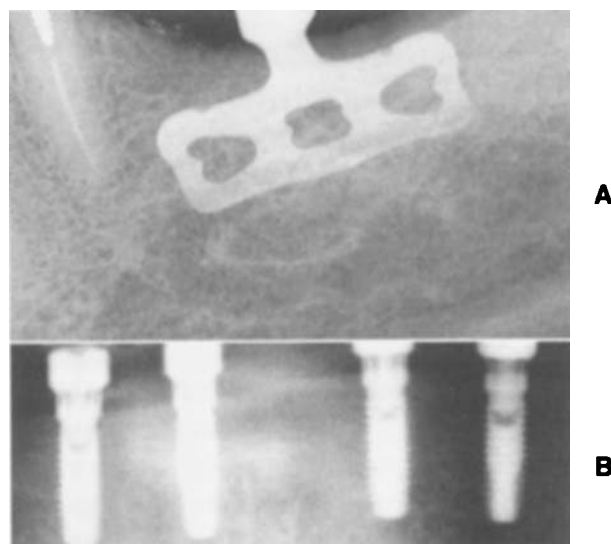


FIG. 9-17 ■ Postinsertion radiographic check of plate/blade form (A) and root forms (B).

After careful checking to evaluate that each step of the procedure appears to have been successful, this radiograph now serves as part of the patient record.

Final Closure—Suturing

Coapt the tissue flaps, and press them against the underlying bone. Use an atraumatic needle and 3-0 black silk or its equivalent for suturing. Interrupted suturing is generally the method of choice. In endosteal cases that follow the two-stage submerged healing protocol, place a series of sutures 2 to 3 mm apart along the length of the incision. Inspect and fill in unsutured areas carefully. In the case of two-stage healing collars and one-stage abutments, sutures are first placed mesially and distally. Next, sutures are placed every 2.5 mm along the entire incision line. Inspect and fill

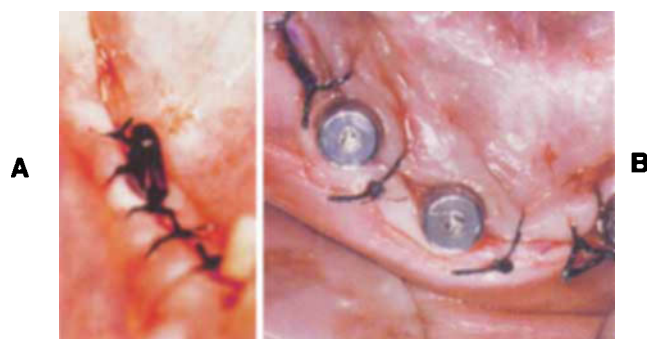


FIG. 9-18 ■ Closure with interrupted sutures in plate/blade form case (A) and root form case (B).

in as required with additional sutures (Fig. 9-18). Using damp gauze, compress the flaps against the underlying bone.

The sutures at the mesial and distal of the healing collars and abutments are angled toward the lingual midpoint of the abutment or healing collar. In this way, as the sutures are tightened, tissue is securely wrapped around each. Always secure a good bite of tissue, preferably within the band of attached gingiva. If flap thickness was reduced, ensure that the sutures penetrate into tissue below the removed wedge, so the upper section with the gingival epithelium will be pulled snugly against it. Successful suturing is an extremely important aspect of implant insertion. Securely sutured flaps heal rapidly by primary intention, with significantly reduced edema.

Shade Selection

Using one's preferred guide, select the shade for the laboratory. This shade will be used for the final restoration, as well as for any provisional restorations that may be used in the course of treatment, depending on the modality used and the location of the treatment.

Shade selection will be checked during the try-in visit, or at any other desired time during treatment, and modified if required.

Postinsertion Home Care Instruction

Trauma. Mild edema usually is observed. Cold application may be advised. Ibuprofen (Motrin), a mild anti-inflammatory agent, is supplied for patient comfort.

The patient is advised that edema, if it occurs, usually peaks at the second to third day, and subsides thereafter. The influence of gravity usually shifts the edema inferiorly as it subsides.

Rarely, a mild hematoma may be observed. This occurs in few patients, with very little trauma.

The patient is advised that a hematoma will change color and resorb within several days. Makeup can be helpful for masking. It is important to advise the patient of all possibilities, so that if they occur, unnecessary anxiety may be avoided.

Prophylactic Antibiotic Medication. A prescription is written, usually for the same antibiotic that was prescribed preoperatively. The postoperative prescription may have been written as a refill with the preoperative prescription.

The patient remains on antibiotic therapy for 5 to 7 days, depending on the antibiotic prescribed, the patient's hygiene and general health, and the degree of insertion trauma. Note that when the proper insertion protocol is followed, postinsertion infection during the healing period is almost never observed.

Comfort Medication. Extremely apprehensive patients are uncommon. In such cases, a long-action local anesthetic such as bupivacaine hydrochloride and epinephrine (Marcaine) can be administered at the end of the procedure.⁸

Administering a long-action local anesthetic provides complete comfort for several hours postoperatively.

Routinely, a prescription is written for pain relief. Ibuprofen 400 mg is suggested, one every 4 to 6 hours only if necessary. Alternatively, if not contraindicated, Tylenol No. 3 labeled for use in the same way can be prescribed.⁹

Prescribing an analgesic reassures the patient that, if necessary, they have what they need for comfort. Most patients report that they required little or none of the analgesic.

Cleanliness. The patient is advised not to brush his or her teeth for 24 hours. Starting on the second day, a soft toothbrush is used gently to cleanse the provisional prosthesis if one is used. Rinsing two to three times a day with a solution of a level teaspoon of salt dissolved in a glass of warm water, or with chlorhexidine, is helpful. Rinsing also should be started on the second day.

Avoiding any contact with the involved tissues or sutures is advised during the first 24 hours of healing. When the soft toothbrush is used, only the prosthesis is cleaned, and the tissues and sutures are avoided. Rinsing serves two purposes. First, the lavage action cleanses the tissues adequately. Second, the warmth dilates the blood vessels to promote healing and the delivery of antibiotic to the area. In addition, hypertonic saline may decrease inflammation through osmosis.

Diet/Function. A soft diet is essential at this time, regardless of the modality and mode of tissue integration selected for the case. Soup, yogurt, liquid drinks, purees, scrambled eggs, cooked cereals, and the like are excellent.

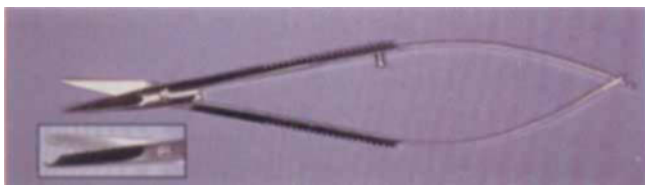


FIG. 9-19 ■ Noyes scissors or suture scissors (*inset*) to facilitate suture removal.

Prepared nutritional supplements or full-value liquid protein regimens can be helpful. Patients who have digestive or other medical problems may wish to consult with their physicians. This soft diet must be continued until healing has progressed past the point at which increased function can compromise tissue integration. Smoking is prohibited.^{10,11}

A condition of afunction or controlled hypofunction, dictated by the healing protocol for the case at hand, is essential during healing of the implants. Provisional teeth, if used, are for esthetics only.

Postinsertion Follow-Up Visit

General Evaluation. A follow-up visit is scheduled 7 to 10 days postinsertion. Earlier visits are generally not required. Patient progress and experiences are evaluated.

Patients generally report minimal edema that subsided during the week and, rarely, hematoma. Most often, the comfort medication was not taken. Always check that the antibiotic regimen was followed, that the no-smoking rule was observed, and that the diet has been and will continue to be appropriate.

Suture Removal. Remove the provisional prosthesis, if present, for better access to facilitate suture removal. A suture scissors or Noyes scissors and fine-tissue forceps are used. Either of these scissors slips under each suture atraumatically to sever it (Fig. 9-19). The forceps is used to remove the suture. Apply a medicament over the area, such as tincture of benzoin USP.

Suture removal should cause little or no discomfort. Suture or Noyes scissors easily slip under the suture, even in areas of difficult access, preserving patient comfort.

Soft-Tissue Healing. Check that healing is by primary intention. Observe the tissues around healing collars and abutments. Medicate as required.

There usually is little or no problem at this juncture.

Check Provisional Removable Prosthesis. The provisional prosthesis, if present, is replaced following suture removal. First, look for signs of sore spots on the gingiva, and adjust accordingly. Recheck and adjust the occlusion if required.

These details are important. Anything that promotes gingival health and ideal healing is worth the effort. Case sequencing can be maintained when every step of the procedure is carefully performed, checked, and adjusted as required.

AFTERCARE AND MAINTENANCE

Professional Maintenance

Regardless of a patient's ability to perform acceptable and thorough home care, professional maintenance is essential. Some portions of the restoration and the pergingival implant sites cannot be adequately maintained at home. Following completion of treatment, patients are recalled at 3 months. The frequency of recall for professional maintenance thereafter depends on the adequacy of home care and clinical observations at the first recall visit. Diligent patients follow a cycle of 3 months for the first recall, then 4 months, and then every 4 to 6 months thereafter, as required. Most patients are recalled every 3 to 4 months.

Solid titanium or graphite curettes are extremely helpful for implant maintenance (Figs. 9-20 and 9-21). Plaque and tartar buildup does not adhere very firmly to polished coronal areas of implants or restorations, so little danger exists of overabrasion of their surfaces with these instruments. Some patients present at recall with substantial plaque and calculus (Fig. 9-22), which can be completely removed (Fig. 9-23). Occasionally, if screw loosening is observed, the screw is tightened with the appropriate torque wrench (Fig. 9-24). Overdentures, if used, are cleansed and resealed.

All patients are checked for stability of occlusion, which is adjusted if necessary. Early changes in bone contours and height are noted and treated as required.

Patient Maintenance/Home Care

There is no substitute for excellent, thorough, ongoing home care by the patient. Following the completion of a well-executed case, if a complication arises it is often due to lack of patient maintenance. This not only pertains to home care. Proper patient maintenance requires that the patient be made as responsible as the treating practitioner to ensure the performance of professional maintenance on a regular, scheduled basis.

The Bass method of toothbrushing is beneficial for home maintenance. It is relatively easy to instruct a patient in this technique (Fig. 9-25). Patients are taught how to floss an implant sulcus (Fig. 9-26) and coping/bar components with floss, tape, ribbon, and/or gauze (Figs. 9-27 and 9-28). Instruction in the use of a proxy brush and rubber

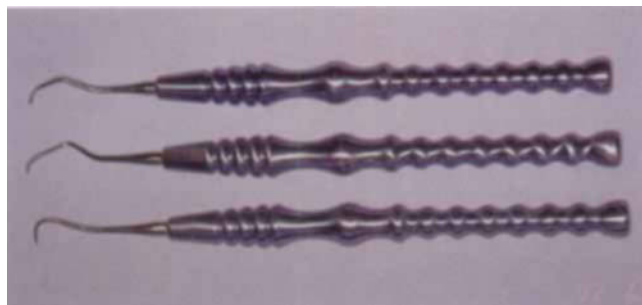


FIG. 9-20 ■ Set of solid titanium curettes for professional implant maintenance.



FIG. 9-21 ■ Removal of calculus with a graphite curette. (Courtesy Karima Bapoo-Mohamed, RDH, Edmonton, Alberta, Canada.)



FIG. 9-22 ■ Plaque and calculus at recall. (Courtesy Karima Bapoo-Mohamed, RDH, Edmonton, Alberta, Canada.)



FIG. 9-23 ■ Ideal results following professional maintenance. (Courtesy Karima Bapoo-Mohamed, RDH, Edmonton, Alberta, Canada.)



FIG. 9-24 ■ Tightening a loose screw with a torque wrench. (Courtesy Karima Bapoo-Mohamed, RDH, Edmonton, Alberta, Canada.)

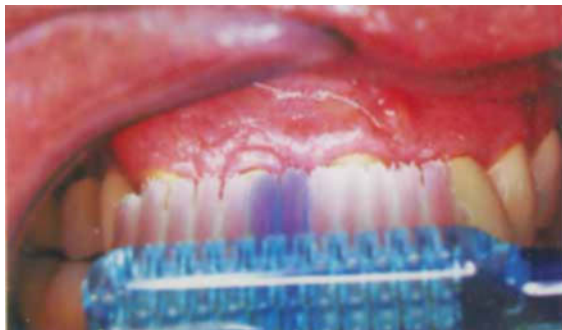


FIG. 9-25 ■ Recommended toothbrush positioning. (Courtesy Karima Bapoo-Mohamed, RDH, Edmonton, Alberta, Canada.)



FIG. 9-26 ■ Crisscross positioning of floss around an implant sulcus. (Courtesy Karima Bapoo-Mohamed, RDH, Edmonton, Alberta, Canada.)

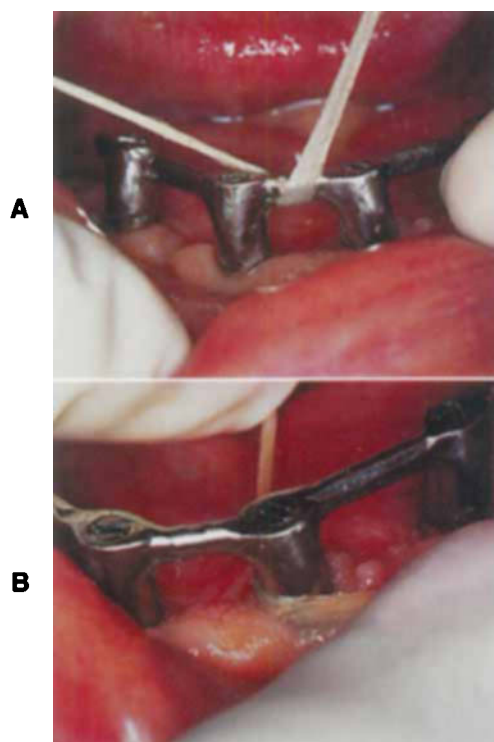


FIG. 9-27 ■ Floss (A) and tape (B) positioning for final coping/bar polishing. (Courtesy Karima Bapoo-Mohamed, RDH, Edmonton, Alberta, Canada.)

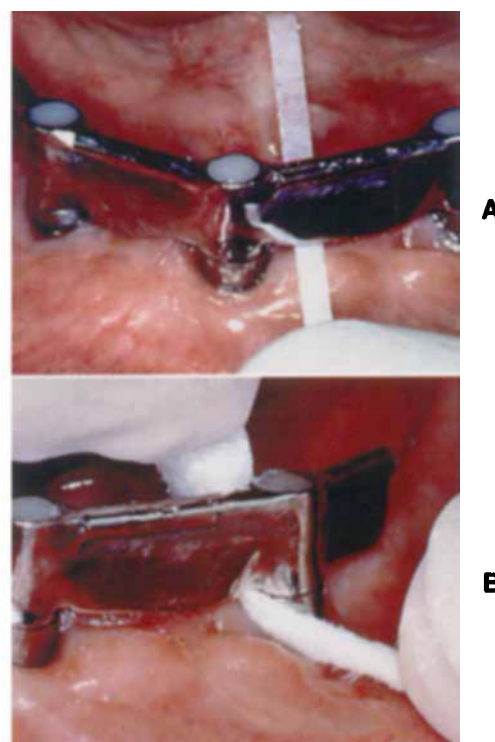


FIG. 9-28 ■ Ribbon (A) and gauze (B) positioning for final coping/bar polishing. (Courtesy Karima Bapoo-Mohamed, RDH, Edmonton, Alberta, Canada.)

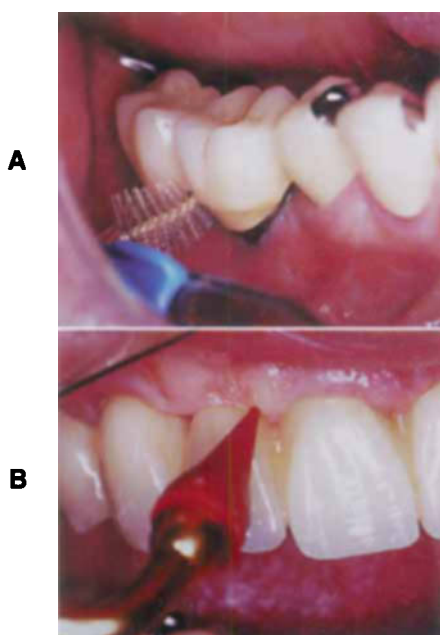


FIG. 9-29 ■ Positioning of proxy brush (A) and rubber tip (B) for interproximal prophylaxis. (Courtesy Karima Bapoo-Mohamed, RDH, Edmonton, Alberta, Canada.)



FIG. 9-30 ■ Examples of well-maintained implant sulci. (Courtesy Karima Bapoo-Mohamed, RDH, Edmonton, Alberta, Canada.)

tip is also given (Fig. 9-29). Healthy implant sulci are the result (Fig. 9-30).

There is no doubt that the combination of effective professional and home care maintenance significantly contributes to a positive prognosis for the case.

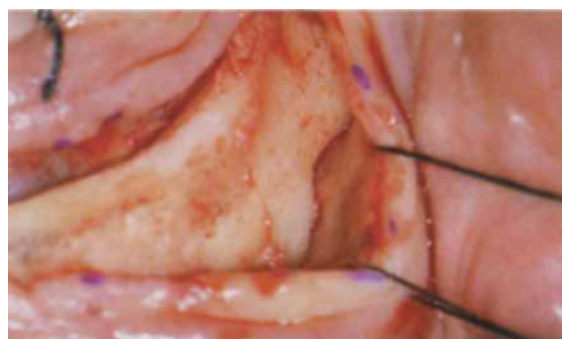


FIG. 9-31 ■ Crestal reduction to ensure adequacy of ridge width. Note area of mental foramen.

COMPLICATING AND ATYPICAL CONDITIONS

Frequency of Occurrence

Complicating and atypical conditions related to implant insertion and restoration are rare. The absence of the tendency toward these conditions is one of the criteria for identifying a case as mainstream. However, in marginal cases, and in cases in which certain conditions are not readily recognized or diagnosed in advance, a complicating or atypical condition may occur during treatment. If so, treatment may proceed in almost every case. Only rarely does an atypical or complicating condition require one to abort treatment or refer to a more experienced practitioner, if the case was appropriately diagnosed as mainstream.

Questionable Adequacy of Ridge Width

Adequacy of the ridge width is always a consideration when using an endosteal implant modality. It is less applicable to subperiosteal implants. At the ridge crest, it is optimal to have 1 mm of bone width between the inserted implant and the lingual and buccal/labial cortical plates. Half a millimeter can suffice, if necessary. If less bone width is present, the ridge height may be reduced to create more width at the crest (Fig. 9-31). If this is done, be sure to reassess the depth of bone at the osteotomy site to ensure that clearance from nerves, foramina, and other landmarks is still adequate. If not, choose a shallower implant and proceed with treatment. This situation shows the value of having a back-up implant ready, or even better, a small stock of implants of various modalities and configurations for unexpected situations. Another option in mainstream cases is to use bone compactors or ridge expanders when but a few millimeters of added width would be desirable. This technique is described in Chapter 12.

Minimal Width of Attached Gingiva

Minimal width of attached gingiva can be recognized before the start of treatment (Fig. 9-32). It may not exist along the entire length of the edentulous area that will re-



FIG. 9-32 ■ Marked borders between attached and unattached gingiva.

ceive the implants. The area of concern is that portion of attached gingiva that will be around an abutment at the pergingival site. Because attached gingiva is desirable around the entire periphery of each abutment, the attached gingiva that is present preoperatively must be handled carefully in an effort to preserve it. The first time this must be considered is when the incision is made before tissue reflection. In the area of the proposed pergingival site, incise precisely in the middle of the attached gingiva. This gives the maximum amount of attached gingiva possible on each side. During tissue reflection of the gingival flaps, use a fine periosteal elevator in this area, and reflect the tissue as gently as possible. Try not to tear tissue. Another time to be careful to preserve attached gingiva is following implant insertion, during tissue punching around each healing collar or abutment. In cases of minimal width of attached gingiva, do not tissue punch. Because the tissue is thin, it will adapt well, with little bunching.

Frayed/Torn Flap(s)

If one or both flaps are torn during reflection, trim the torn edges according to the principles described during the suturing procedure to ensure healing by primary intention. If the tear is so severe that too much tissue would have to be removed to produce an even edge, resulting in unwarranted tension at the suture line, trimming should be limited. In this case, use 4-0 interrupted silk sutures to close the tear carefully before and/or after normal suturing to provide the best access to and stability of tissue.

Excessive Bleeding

Prevention is everything. Most bleeding occurs from soft tissue. Careful reflection of gingival flaps and visual verification that the elevator is between the periosteum and

bone during tissue reflection will prevent most problems of excessive bleeding. Excessive bleeding can occur as a result of a soft-tissue incision or tear. If this occurs, unless medically contraindicated, deposit a few drops of local anesthetic containing 1:100,000 vasoconstrictor directly into the area. This usually solves the problem. If not, dampen a 2-inch gauze square, and apply direct pressure. Sometimes, excessive bleeding wells up from the bone in a freshly prepared osteotomy. Direct pressure can be helpful in such cases. Final seating of the implant almost always controls such bleeding. To avoid the possibility of incorporating fibers within an osteotomy, do not apply gauze directly to bone.

Presence of a Retained Root Tip, Cyst, or Granulomatous Tissue

The presence of a retained root tip, cyst, or granulomatous tissue can be detected before treatment, and/or observed during treatment. It is removed carefully, and the affected areas are curetted cleanly. The insertion procedure then continues as it would have in the absence of this complication. Bone will fill the curetted voids following clot formation to initiate the healing process. Minor augmentation may be helpful.

Unusual Variation in Ridge Height and/or Contours

At times, the contours of the ridge crest vary greatly from mesial to distal, especially in height. This can result from the removal of teeth at different times or prior asymmetrical periodontal complications. If the height variation is too great to ignore, gentle ramping with a bone file or bone bur to even discrepancies is advised. Although bone should be altered as little as possible to avoid resorption, excessive variation of ridge height is a case in which altering bone is advisable. When reducing crestal height, recheck depth measurements to the nearest landmark to ensure the implant configuration chosen is still of appropriate depth for safety.

Following ridge height alteration, coapt the reflected tissues before the start of implant osteotomy preparation, and if bunching occurs, trim the flap edges. Be sure not to remove too much attached gingiva. If in doubt, position the tissues more apically and, using wet gauze, press to attach the sutured flaps against the newly contoured ridge crest.

Osseous Perforation During Osteotomy Preparation

Osseous perforation during osteotomy preparation is only a possibility when using an endosteal implant modality. It is not applicable to subperiosteal implants. Osseous perforation can occur either because an unexpected concavity in a cortical plate is encountered at some point along the depth of the osteotomy, or more commonly, because of in-

accurate angling of a **pilot drill** or bur in attempting to bisect the cortical plates. In either case, raise the pilot drill or implant bur crestally, correct the angle to bisect the cortical plates, and complete formation of the osteotomy. A perforation will heal. The prognosis should not be adversely affected. A simple augmentation procedure can be performed, if desired.

Fracture of Osteotomy Wall

Fracture of an osteotomy wall is only a possibility when using an endosteal implant modality. It is not applicable to subperiosteal implants. Fracture of an osteotomy wall rarely occurs. When it does, the procedure may not have to be aborted. The cause usually is osteotomy drilling in a ridge of marginal thickness, injudicious testing of an osteotomy with an implant try-in, counterboring for final placement of certain types of root form implants, or injudicious trial seating of a plate/blade form implant.

If at least two thirds of the coronal portion of a seated implant is at or under the ridge crest in the area of the fracture, and the remainder of the buccal/labial or lingual is in place, do not abort. Simple augmentation may be considered.

Sinus Perforation

Panoramic and periapical radiographs clearly show the inferior extent of the sinus. However, in sagittal sections, the sinus is ovoid. Medial to the lowest point there usually is available bone that cannot be observed on a radiograph. Thus, sinus penetration cannot be definitively determined on a periapical or panoramic radiograph. Clinically, during implant osteotomy preparation or implant insertion, the sinus may be penetrated. If this occurs, seating the implant will seal the penetration. If an excessively deep implant configuration was incorrectly chosen, replace it with a shallower configuration. If a radiograph suggests possible sinus penetration after the implant has been inserted, monitor the healing process. Secure suturing permits uneventful soft-tissue healing, which helps to avoid other sequelae. Minimal sinus penetration is not a reason to abort treatment.¹²

Paresthesia

Every precaution should be taken to avoid paresthesia. Paresthesia can occur as a result of abrasion of a nerve, usually as a result of encroaching upon the mental foramen or the mandibular canal. This can be avoided by assiduous attention and rigid adherence to the details of the implant selection and osteotomy preparation protocols, particularly the guiding measurements before drilling. A paresthesia can either be transient, in the case of minor abrasions, or more persistent in cases of more significant nerve injury. If an implant is not impinging against a nerve, time is the best treatment because it allows one to assess the severity of the condition. Paresthesia may occur when

inappropriate configuration selection results in the insertion of an implant that is too deep, or when a correctly chosen implant is positioned such that it impinges on a nerve. If an immediate postinsertion radiograph reveals impingement, remove the implant and either create a new osteotomy close by or insert a shallower implant that can still withstand the anticipated occlusal load. Then monitor the patient. Prevention is everything. There is no substitute for exacting execution of the step-by-step procedures for implant selection and insertion.

Implant Insertion In or Over New or Partially Healed Extraction Sites

Implants can be inserted at the time of tooth extraction if conditions are appropriate. In mainstream cases, the entire socket is obliterated during osteotomy preparation, and infection or inflammation, if present, is minimal, and is being treated with antibiotics.

Friable Tissue at Suturing

Some patients present with extremely thin, friable tissue overlying the ridge. Such tissue tends to tear during suturing. This may compromise healing by primary intention and can lead to dehiscence. The solution has several aspects. Try using 4-0 atraumatic silk sutures. Do not suture with more tension than is required for closure. If in doubt, place more sutures. Also, take a larger bite with each penetration, and following suturing, compress the tissue with wet gauze to paste it down firmly against the underlying bone. Rinsing starting on the second day should be limited and gentle to help ensure that neither the tissue nor the sutures will be disturbed.

Excessive Postoperative Edema

If the patient's history suggests an inclination toward excessive edema, preoperatively prescribe a corticosteroid dose pack (Medrol). Prescribe allowance for one refill in case excessive postoperative edema is persistent. In such cases, the prescription should be refilled. If the excessive postoperative edema was not anticipated, prescribe the dose pack for the first time postoperatively. The edema will subside, either as a result of the medication or naturally over time. In any event, excessive postoperative edema rarely is observed and most often is not a cause for concern. Be sure to inform the patient of this possibility preoperatively.

Retained Impression Material

Occasionally, remnants of impression material remain unobserved. If so, the reaction of the gingival tissue and underlying bone may be severe. If clinical examination leads to suspicion of retained impression material as the cause of a tissue reaction, explore carefully and remove any retained impression material that may be found. The tissue

will quickly recover if this is done in a timely manner. Long-term retained impression material may compromise prognosis, often severely. Prevention is the key. Always be sure to inspect carefully for retained impression material following its use.

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10 Root Form Implants

Treatment of Total Mandibular Edentulism Diagnosed for an Overdenture

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BENEFITS AND DESCRIPTION OF THE MODALITY AND SYSTEM USED IN THE TEACHING CASE

This chapter describes patient selection, diagnosis, treatment planning, and case sequencing for the treatment of total mandibular edentulism using root form implants and overdentures.

Threaded, parallel-sided configurations are commonly used root form implants. They have a long record of safety and efficacy. In the case of threaded implants, the insertion protocol and armamentarium are a bit more complex than those associated with **press-fit implants**, for which the protocol is more easily mastered. However, the mainstream use of parallel-sided threaded implants anteriorly in the mandible as support for overdentures is ideal, because of the abundant available bone found in this area. Two, three, or four individual or splinted implants are typically used.

Nobel Biocare/Steri-Oss implant systems are supported by university-based research and clinical trials,^{1,2} representatives of which are thoroughly presented in Chapter 8. Their Rosenlicht Hex-Locked (RHL) Immediate Impression Implant System is discussed in this chapter.

Mode of Tissue Integration

As a rule, root forms must osseointegrate to succeed in function long-term. In the teaching case in this chapter, protected implant healing is sequenced to achieve osseointegration.

Preparation for Treatment

Diagnosis and treatment planning are routine. Periapical radiographs, supplemented by panoramic radiographs if desired, are all that are required.³ Out-of-office radiography is not required for mainstream cases. Posteriorly, the use of the root form modality necessitates special consideration

during the planning stages because many ridges cannot accommodate the diameter or depth of these implants. This is not as much of a concern in the anterior, where there tends to be ample available bone, and if necessary, the crest can usually be ramped down to create required width without compromising the depth requirement. One special consideration during the planning stages is the necessity for proper positioning of the implants under the overdenture. Preinsertion **positioning stents** can be adapted from the patient's previous denture if appropriate, or fabricated using waxed-up mounted casts. Little else needs to be done during the planning stages, other than making a commitment to follow the treatment protocols outlined in this chapter.

Technique-Permissive Implant Insertion

The technique of inserting the implants is straightforward and easily mastered. Following the treatment protocol is of vital importance but is not demanding. This protocol ensures the desired mode of tissue integration by applying the appropriate case sequencing and ensuring afunctional healing.

Proven Long-Term Success/Survival Rates

The root form has been more thoroughly researched than any other implant modality. It is widely understood to be safe and effective for its intended purpose of providing additional abutment support for prosthodontic restoration. Again, several seminal studies related to this modality are analyzed in detail in Chapter 8.

Unique Features

The Nobel Biocare/Steri-Oss RHL Immediate Impression Implant System is available with three surface treatments: etched titanium, used in this chapter; hydroxyapatite



FIG. 10-1 ■ Etched titanium, hydroxyapatite, and titanium plasma spray surface treatments.



FIG. 10-2 ■ Immediate impression transfer coping assembly.



FIG. 10-3 ■ O-rings—one of various overdenture attachment mechanisms.

(hydroxyl **apatite**); and titanium plasma spray (Fig. 10-1). The implants are available in four diameters and six depths. The immediate impression assembly has three symmetrical sides that coordinate with the implant hex (Fig. 10-2). This design allows for simple, precise placement of **transfer copings** into the impression by aligning any flat on the impression assembly transfer coping with any flat recorded in the impression.

Use of the Nobel Biocare/Steri-Oss RHL Immediate Impression Implant System decreases chairside time and total treatment time. In cases to be restored with fixed crown and bridge, it promotes early esthetic temporization, leading to greater patient satisfaction. In the teaching case in this chapter, it greatly simplifies the prosthodontic considerations related to splinting and bar retention under overdentures.⁴

The attachment mechanisms discussed in this chapter are simplified. Just a few components from the many that are available are presented to promote ease of understanding, simplify prosthodontic protocols, and increase technique-permissiveness. Additional specialized components not used in this teaching case are available to accommodate various treatment planning possibilities (Fig. 10-3).

Configuration and Nomenclature of the Implants Used in the Teaching Case

The root form implants used in the teaching case described in this chapter are 12-mm deep RHL externally hex-locked parallel-sided 3.8 mm-diameter implants with 4.1 mm-diameter hexed platforms, fabricated with the etched-titanium interface with a 1-mm smooth **coronal** region at the crest (Fig. 10-4). The teaching case uses implants with the industry standard **external hex** and thread. A titanium **cover screw** and transfer coping are included with each implant supplied by the manufacturer. To accommodate the various dimensions of available bone encountered in mainstream cases, the implants are available in a selection of diameters and depths.

All implants within this system are available in six depths: 8, 10, 12, 14, 16, and 18 mm. In describing the dimensions of these RHL externally hexed implants, both the diameter of the implant body and that of its hexed platform, which are generally not the same, are listed. Implant diameters in general relate to the size of the hexed platform to which the retention mechanism is mounted. RHL implants of 3.25-mm diameter have an equal diameter of the body and the hexed platform. Implants with a 3.8-mm or 4.5-mm body diameter have a hexed platform diameter of 4.1 mm (denoted as 3.8/4.1 mm and 4.5/4.1 mm, respectively), and those with a 4.5-mm body diameter have a 5.0-mm diameter hexed platform (denoted as 4.5/5.0 mm).

Prosthodontic components available for fabricating the retentive mechanism for the overdenture include prefabricated 3.8/4.5 hex-locked (HL) overdenture abutments of various heights to accommodate the soft-tissue thickness where the abutment will emerge. Overdenture abutments

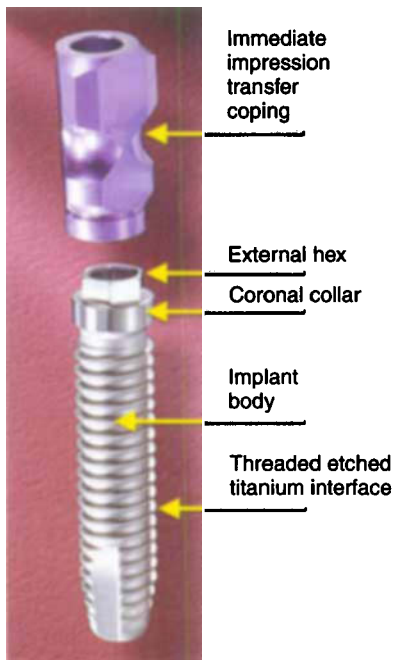


FIG. 10-4 ■ RHL externally hexed parallel-sided etched titanium implant.



FIG. 10-5 ■ Overdenture abutments and an attached analog (below arrows).

are available in heights of 1.5, 2.5, 3.5, and 4.5 mm, as are the **overdenture abutment analogs**, and are supplied with appropriate retaining screws (Fig. 10-5).

The prosthodontic components are available in diameters that correspond to each available hexed platform diameter.

A flowchart of the prefabricated attachment component options for overdenture restoration is illustrated in Fig. 10-6. Implant overdenture abutment universal analogs are supplied in one length sufficient for firm incorporation within the master model.

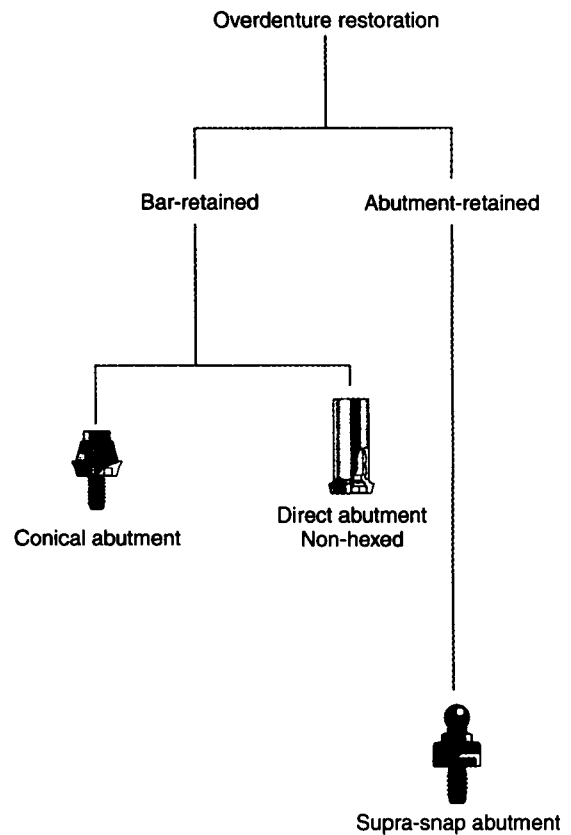


FIG. 10-6 ■ Flowchart of attachment components for overdenture restoration.

TYPICAL MAINSTREAM CASE—DIAGNOSIS, TREATMENT PLAN, AND END RESULTS

Case as Presented

Patient's Story. A typical mainstream case presents with complete edentulism in the mandible. The maxilla may have a complete denture, natural teeth, or various combinations of natural teeth, implants, and/or removable partial dentures. It is preferable to treat one's first few cases opposite a maxillary complete denture.

The patient may complain of insecurity related to his or her lower denture during eating or talking. Primary denture retention and stability may be lacking. This results in poor mastication, inability to eat without being conscious of it, and inability to speak extemporaneously for fear of denture detection. Often there are complaints related to gingival tissue irritation.

Clinical Appearance. Examination reveals a loose, perhaps unesthetic denture; poor hygiene; some loss of crestal height; and an adequate width of attached gingiva. Facial contours may be compromised, and interocclusal clearance reduced. In mainstream cases, in addition to a broad band of attached gingiva, one usually observes adequate anterior labio-lingual ridge width (Fig. 10-7).

Radiographic Interpretation. Periapical radiographs reveal adequate length and depth of mandibular anterior



FIG. 10-7 ■ Preoperative view of typical mainstream case.

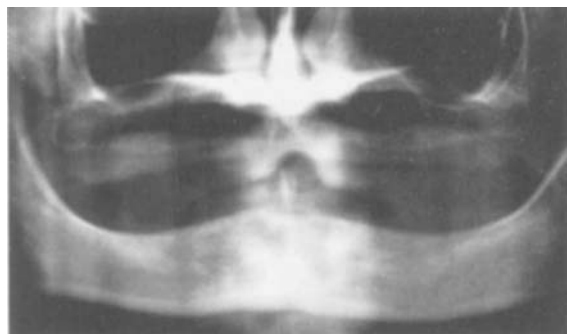


FIG. 10-8 ■ Preoperative radiograph of available bone.

available bone to accommodate the insertion of a sufficient number of implants to provide the necessary support for an overdenture with retentive components that will withstand anticipated functional loads long-term within physiologic limits of health. The landmarks and osseous borders are clearly identified on the radiographs (Fig. 10-8).

Rejected Alternative Treatment Plans

The patient and the practitioner do not believe that a new complete mandibular denture would be satisfactory. The status quo is also unacceptable, for the conditions causing the complaints would remain and become exacerbated over time. Therefore, implant treatment is indicated. A total mandibular subperiosteal implant is not indicated in this case. There is too much alveolar bone, which would continue to recede after placement of a subperiosteal, causing complications in the future. Plate/blade forms may be indicated, but because of significant change of facial contours requiring a degree of correction available only with acrylic flanges, root form treatment with an overdenture restoration was selected as the treatment plan. Most complete arch plate/blade form and many complete arch subperiosteal cases, which are not considered mainstream because of relative complexity, use fixed restorations. It is not advisable to splint plate/blade forms to each other without natural co-abutment support unless they turn the arch. For these reasons too, root forms in the anterior mandible are the method of choice for a complete overdenture.

BOX 10-1 ■ VISIT-BY-VISIT TREATMENT OBJECTIVES

Preoperative procedures: diagnosis and treatment planning

Visit 1: Implant insertion, direct bone impression, and inter-arch occlusal registration

Visit 2, week 1: Suture removal

Visits 3 to 6, weeks 3 to 12: Patient visits related to overdenture fabrication

Visit 7, week 16: Implant exposure, attachment of splinted custom abutment clip bar assembly for overdenture retention

Visits 8 to 10, weeks 17 to 18: Adapting the overdenture to the retention mechanism and case completion

Accepted Treatment Plan—Visit-By-Visit Case Sequencing and Timing

The objectives of each of the treatment visits for the teaching case in this chapter are listed in Box 10-1. It is important to have a basic understanding of the entire course of treatment in advance, so that one can appreciate how each step in the procedure presented in this chapter contributes to ultimate success.

Completed Case

Having the goal of treatment firmly in mind during each patient visit is important. Every step in the procedure is directed toward successful completion of the case. Therefore, the end result is presented here, to help the reader understand how each treatment step contributes to the final objective, and to convey the satisfaction and benefits of treatment both for the patient and practitioner.

Patient's Story. The treatment goals have been achieved. Primarily because the complete maxillary removable denture with which the patient presented was so well conceived, the esthetics of the case are excellent. The mandibular overdenture blends in color and tooth form. The position of the teeth permitted a fine result.

Of greater benefit, of course, is the enhanced support, retention, and stability of the mandibular overdenture. The patient has far less anxiety when speaking or laughing. The ability to chew well and without being aware of it is much appreciated. Stage one of the overdenture fabrication was well executed during the critical period of semi-submerged or submerged implant healing. Stage two consisted of the incorporation of the attachment mechanism within the overdenture, which afforded efficient retention and stability such that movement was minimized. Therefore, required adjustments for tissue irritation and sore spots were minimal. This patient is pleased and grateful not only with the result but with the ease of the entire course of treatment.

Clinical Appearance. The appearance of the finished case centers on the original well-conceived complete maxillary denture (Fig. 10-9). If the original denture were not ac-



FIG. 10-9 ■ Postoperative view of seated completed prostheses.

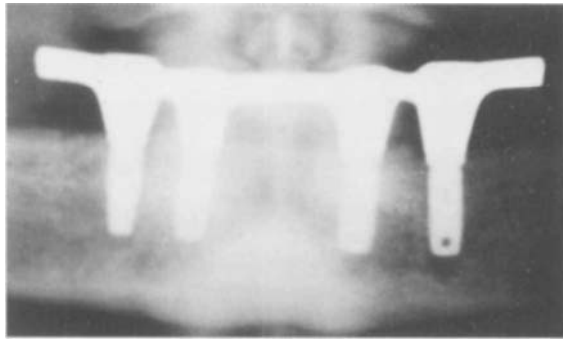


FIG. 10-10 ■ Postoperative radiograph of a completed case.

ceptable, it would have been not only wise, but essential to include the fabrication of a new maxillary denture in the treatment plan. The positioning of the maxillary teeth has a direct effect on those of the mandible, often requiring the treatment plan of mainstream cases to include the fabrication of a new maxillary denture. Quite often, following the success of the mandibular implantation and overdenture treatment, the patient requests similar treatment in the maxilla. When the dimensions of the residual alveolar ridge in the anterior maxilla are sufficient, such treatment can be performed. In edentulous cases of marginal or insufficient bone anteriorly, the diagnosis for an overdenture is not mainstream. Treatment may require complex bone augmentation. Mainstream treatment for a maxilla with limited available bone could include the use of intramucosal inserts. This modality provides immediate enhanced retention and stability to a maxillary removable denture. Treatment using intramucosal inserts is covered in Chapter 20.

Radiographic Interpretation. The postoperative panoramic radiograph reveals well-positioned implants. The landmarks and borders surrounding the implants have not been abridged or traumatized. Most often, one implant is placed about 3 to 5 mm anterior to the mental foramen on each side, usually in the area formerly occupied by the first premolar, and one implant is positioned on each side of the midline, for a total of four implants. The postoperative radiograph reveals harmony of the axial inclination of the implants, the result of careful planning and execution of treatment (Fig. 10-10).

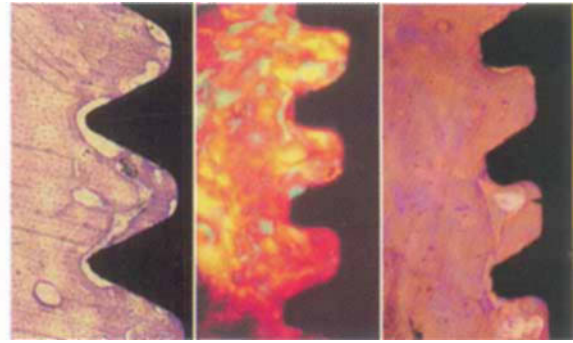


FIG. 10-11 ■ Osteointegration around healed implants.

BOX 10-2 ■ PREOPERATIVE PROCEDURES

- Quantify available bone
- Select ideal implant configurations
- Select overdenture retention components
- Fabricate implant positioning stent
- Prescribe preoperative medication

Microscopic Interpretation at the Interface. Following healing, microscopy reveals bony ingrowth within the implant threads (Fig. 10-11) and excellent maintenance of crestal bone height. The amount of direct bone apposition and its distribution demonstrate an excellent example of successful osteointegration. There is more cortical bone in proximity to each implant in the anterior mandible than in any other location in the dental arches.

PLANNING AND PROCEDURES BEFORE IMPLANT INSERTION

The steps that are performed before the implant insertion visit are shown in Box 10-2.

Quantify the Available Bone

Having determined that the osteointegration mode of tissue integration must be used in this case, the next step is to quantify the available bone in the areas targeted for implant insertion following the principles laid out in Chapters 3 and 9. To briefly review, use periapical radiographs to determine the length and depth of available bone between anatomic landmarks. In cases in which the implants will be inserted into the anterior mandible, such as in the teaching case in this chapter, recall that length of available bone is measured mesio-distally from the midline to the mental foramen on each side. Depth is measured from the crest of the ridge down to the cortical bone at the inferior border, mesial to the mental foramen.

Outline the “usable” available bone on the radiograph to visualize the length and depth of bone into which the

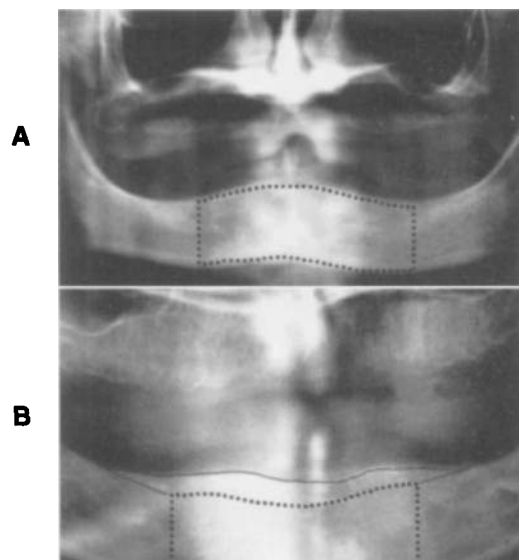


FIG. 10-12 ■ Preoperative radiographs. Mandibles marked to outline available bone (A) and area requiring ramping to obtain adequate ridge width (B).

four implants can be inserted, according to the principles described in Chapters 3 and 9 (Fig. 10-12). The area in Fig. 10-12 bordered by the dotted line represents the usable available bone, and that bordered by the solid line represents bone ramped down in this case to obtain the required ridge width. Width is easily determined in the mandible. Placing a caliper on the gingiva 1 to 2 mm from the crest and subtracting 2 mm from this measurement will accurately give the width of the ridge.

Select the Ideal Implant Configurations for Placement Within the Available Bone

Our first consideration is to ensure that we do not under-engineer the case. This means one must ensure that each implant intended to be splinted or to individually support an overdenture retention component is of sufficient dimensions to function long-term in health under its anticipated load. Anterior implants have an easier job to do than posterior implants in the second premolar and molar areas, which absorb approximately four times more functional force because the musculature there is designed to clench the jaw.⁵ Nonetheless, an overdenture exerts substantial functional force. The implants can sustain this force given adequate available bone. Each patient's strength, habits, and diet bear on the selection of configuration. The implants must be large enough to succeed. If the implants are too small, bone resorption can occur as a result of hyperfunction, which results from **underengineering**. On the other hand, if they are too large, bone resorption can occur because of hypofunction, which results from overengineering. Often, RHL implants of 3.8/4.1-mm diameter and 12-mm depth are used in the anterior to support an overdenture. They offer sufficient interface area

for the typical patient, without over- or underengineering the case.

It is now time to reconfirm that the width of the ridge crest is at least 6.1 mm measured at or approximately 1 to 2 mm below the crest in the positions where implants are to be inserted. In the teaching case the ridge width is sufficient, so 3.8/4.1-mm diameter implants are selected with the comfort of knowing that at least 1 mm of surrounding bone will exist at the buccal and lingual borders.

Viewing the radiograph that was marked earlier to show the usable available bone, the distance from the ridge crest to the cortical bone of the inferior border of the mandible is measured to confirm a depth of at least 13 mm. At least 1 to 2 mm clearance beyond the base of the inserted implant, which is 12 mm in depth, is desirable. If the radiograph indicates adequate depth, as it does in our teaching case, final confirmation is obtained by placing a radiographic overlay of the chosen implant over the radiograph. The radiographic overlay is a clear film supplied by the manufacturer with life-sized representations of every dimension of implant available (Fig. 10-13). Passing the imprint of our selected 3.8/4.1-mm diameter, 12-mm depth implant over the periapical radiograph marked to show the extent of usable available bone, one can observe the exact area each implant will occupy, and the amount of clearance between the implants and the closest landmarks. This step is a valuable final confirmation of the appropriateness of the implant configuration selection. The amount of support afforded by the implant configuration chosen in the teaching case will be sufficient, because the patient has no special history of excessive bruxing or wear and tear resulting from detrimental personal habits. One more consideration is essential. A minimum of 3 to 5 mm of bone is optimal between the distal of an implant and the mental foramen in the mandible. In a typical maxillary case, four implants are used, positioned to clear the anterior palatine foramen and the anterior border of the maxillary sinus on each side. The implants are ordered. When delivered, the manufacturer's control and lot number for each implant are entered into the patient's record.

Shallower and deeper 3.8/4.1-mm diameter RHL implants often are ordered as backups, in case osteotomy preparation necessitates more ridge height reduction than was anticipated, or reveals either very hard dense bone or excessively soft bone at the insertion visit. The shallower configuration can be used in the hard dense bone, whereas if there is sufficient available bone depth, the deeper implant may offer a wider margin of safety in soft bone to guard against hyperfunction.

Select the Overdenture Retention Components

Prosthesis retention in the teaching case is achieved using a splinted custom abutment clip assembly retained by coronal screws (Fig. 10-14). Using custom abutments facilitates prosthodontic restoration, making it as close to conventional restoration as possible. This decision is best made at the time of treatment planning, after selection of



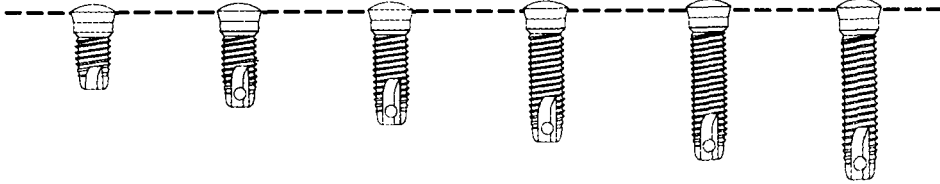
901 E. Cerritos Ave. , Anaheim, CA 92805 USA
(714) 776-9000
(800) 854-9316

HEX LOCK **IMPLANT SYSTEM**

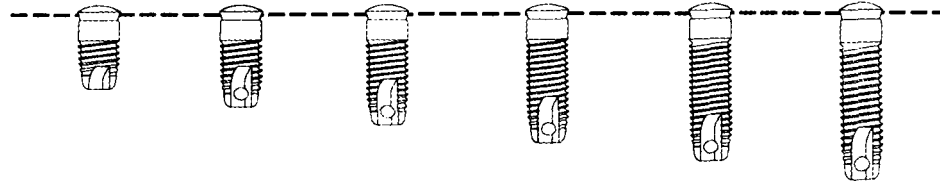
25% Magnification

THREADED SERIES

3.8mm x 8mm #2908/3908HL 3.8mm x 10mm #2910/3910HL 3.8mm x 12mm #2912/3912HL 3.8mm x 14mm #2914/3914HL 3.8mm x 16mm #2916/3916HL 3.8mm x 18mm #2918/3918HL

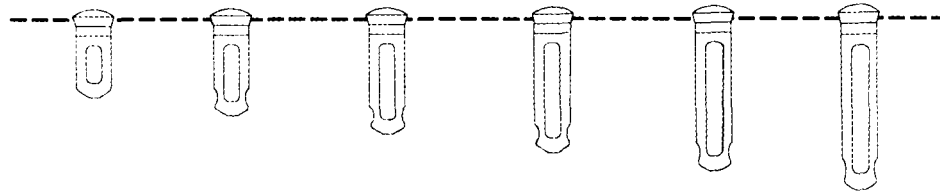


4.5mm x 8mm #4508/4608HL 4.5mm x 10mm #4510/4610HL 4.5mm x 12mm #4512/4612HL 4.5mm x 14mm #4514/4614HL 4.5mm x 16mm #4516/4616HL 4.5mm x 18mm #4518/4618HL



CYLINDRICAL SERIES

3.8mm x 8mm #2808HL 3.8mm x 10mm #2810HL 3.8mm x 12mm #2812HL 3.8mm x 14mm #2814HL 3.8mm x 16mm #2816HL 3.8mm x 18mm #2818HL



DIAGNOSTIC GRID			IMPLANT DIAGNOSTIC GRID		
5mm		30mm	DIAMETER (mm)		
0mm		25mm	CYL 3.25		3.25
5mm		20mm	CYL, THD, BLADE 3.8		3.8
10mm		15mm			4.1
15mm		10mm	HL 4.1		4.5
20mm		5mm	4.5HL 4.5		4.5
25mm		0mm			
30mm		5mm			

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Patent Pending

FIG. 10-13 ■ Transparent overlay to aid in implant selection.



FIG. 10-14 ■ Example of splinted custom abutment clip bar assembly.

the implant configuration, because this dictates the components and implant **analogs** that will be required for treatment. These components are ordered in coordinated dimensions. When delivered, manufacturer control and lot numbers are entered into the patient's record.

Preinsert the Implant Positioning Stent

An implant positioning stent is an effective guide for the placement of each implant. It is important that each implant be positioned properly to enhance esthetics, and to ensure adequate clearance for overdenture attachment and proper occlusion. The crest of the healed edentulous ridge usually is lingual to where the central fossa of the teeth were when they were in position, because the main resorption of bone following the loss of a tooth takes place at the expense of the buccal and labial plates, and also the ridge height. Therefore, the implants should be positioned as close to the buccal of the crestal area as possible while preserving the required 1 mm of bone buccally and lingually. The healed crest is positioned lingual to where the teeth were when they were present. Note again that the distal implants should have at least 3 to 5 mm of clearance from the mental foramen. Optimal implant positioning is also influenced by conditions in the opposing arch. A new opposing denture may need to be fabricated. Preoperative mounted models are sent to the laboratory. There, a removable positioning stent is fabricated, indicating not only the planned location of each implant, but also guiding the planned long axis of drilling for each osteotomy. A well-conceived existing complete lower denture can be adjusted to serve as the removable positioning stent (Fig. 10-15).

Prescribe Preoperative Medication

Prescribe preoperative medication for the insertion visit as discussed in Chapter 9. Recall that preoperative administration of anti-edema medication is generally not suggested for mainstream cases, unless the patient's history suggests that edema may be greater than normal. Nor is preoperative sedation recommended. Patients who take prophylactic aspirin daily are advised to discontinue doing



FIG. 10-15 ■ Preinsertion implant positioning stent—previous denture marked for planned positions of osteotomies.

so for at least 3 weeks preoperatively, to help ensure normal clotting at the insertion visit.

VISIT 1: IMPLANT INSERTION, DIRECT BONE IMPRESSIONING, AND PROVISIONAL PROSTHODONTICS

The steps that are performed during the implant insertion visit are shown in Box 10-3.

Confirm That Preoperative Medication Has Been Taken

As discussed in Chapter 9, it is unnecessary to postpone the case if the patient has not taken his or her preoperative prophylactic antibiotic medication. The practitioner should have antibiotics on hand for preoperative administration in such cases. If a patient on an aspirin regimen has not discontinued its use, insertion may nonetheless be performed, with slightly delayed clotting expected.

■ Instrumentation Setup— The Armamentarium

Two sterile tray setups are recommended. The first, which holds all instruments that do not come in direct contact with the implant during the insertion procedure, is described in Chapter 9.

The second surgical tray holds all instruments involved with implant insertion and protection during submerged

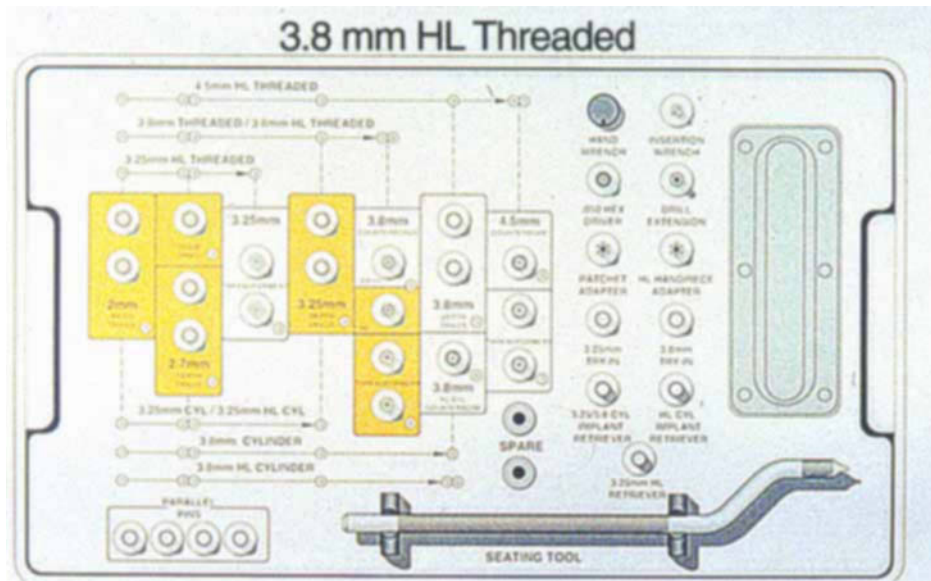


FIG. 10-16 ■ Specialized 3.8-mm HL threaded implant insertion armamentarium.

BOX 10-3 ■ VISIT 1, DAY 1: IMPLANT INSERTION AND IMMEDIATE IMPRESSIONING

Confirm use of prophylactic antibiotic
Set up instrumentation
Administer anesthetic
Target osteotomy locations
Make incision
Reflect tissue
Reconfirm osteotomy locations
Prepare osteotomies
Evaluate suitability of osteotomies
Insert implants
Perform direct bone impressioning
Install healing collars
Perform interarch occlusal registration
Provide soft-tissue treatment
Suture
Select shade
Provide provisional prosthesis
Provide home care instruction
Schedule follow-up visit

or semi-submerged healing, as well as the implants themselves and all implant components, which are packaged sterile. The loaded trays are placed side by side.

For the teaching case, the second tray should include a semi-lunar tissue punch, a 1.5-mm disposable twist drill, a 2.0-mm pilot depth drill, a 2.7-mm pilot **depth drill**, a 3.25-mm depth drill, a 4.1-mm **counterbore**, a 3.8-mm **threadformer**, a hand wrench, an insertion wrench, parallel pins, a ratchet, and a ratchet adapter (Fig. 10-16). In addition, it is advisable to have a 4.2-mm trephine drill, an im-

plant thread cleaning tap, 0.050- and 0.030-inch hex drivers, a slotted screwdriver, a 3.8-mm color-coded green implant try-in, and a surgical driver.

Sterilization is performed before surgery, as with all dental treatment instrumentation.

Presurgical Treatment

Prepare the surgical field, administer local anesthetic containing vasoconstrictor for promotion of comfort and control of bleeding, and prepare the oral cavity and targeted tissues according to the principles and procedures described in Chapter 9.

Score the Ridge to Mark the Selected Position of Each Osteotomy

Place the positioning stent intraorally, and precisely mark the gingiva at the planned incision line, indicating the positions of the mental foramina and the location of each planned implant osteotomy (Fig. 10-17). Remove the positioning stent. With a No. 6 round bur in a contra angle with coolant, penetrate the gingiva and score the bone to a depth of approximately 1 mm at each implant site.

Following incision and tissue reflection, these score marks guide implant positioning. Score marks are created at this point in the procedure because following tissue reflection, the positioning stent may not seat accurately.

Make Incision

Evaluate the attached gingiva, review the location of the planned incision line, incise, and ensure hemostasis



FIG. 10-17 ■ Tissue marked at ridge crest, planned implant insertion sites, and area over each mental foramen.



FIG. 10-19 ■ Ridge crest too thin labio-lingually. Reduction required.



FIG. 10-18 ■ Extent of incision determines extent of reflection.



FIG. 10-20 ■ Reduce height with rongeur to widen ridge crest.

according to the principles and procedures described in Chapter 9.

Following insertion of root form implants, there are two options for closure. The semi-submerged option is used when possible, because the attached gingiva can be positioned and sutured in place around a healing collar that is seated to the body of the implant. When healed, the attached gingiva predictably will be exactly where it was placed. Using the semi-submerged option, the practitioner can ensure this desirable result.

Often, the reflected flaps are sutured completely over the implants for total submersion during healing. This technique has the advantage of full protection during healing, and the disadvantage of requiring a second surgical intervention to expose the implants following healing. Every effort is made to ensure that the cuff around the implant will be in attached gingiva at the time of exposure. However, it may not always be possible to place the implant directly under attached gingiva and at the same time optimally position the implant toward the buccal of the crest to enhance the occlusal relationship. The preferred buccal position is the one indicated on the positioning stent.

To provide adequate access, the extent of the incision should be from the previous position of the second premolar on one side to the corresponding location on the other side (Fig. 10-18).

Reflect and Prepare the Tissue Before Insertion

Reflect the tissue using the periosteal elevator, trim the tissue flap edges to ensure healing by primary intention, and cleanse and alter the exposed alveolar ridge as required according to the procedures and principles described in Chapter 9 (Figs. 10-19 and 10-20).

Reconfirm or Change Location of Implant Osteotomies

Reinspect the ridge crest and observe the location of each of the four planned osteotomies, as indicated by the 1-mm-deep score marks, emphasized in blue in Fig. 10-21, that were created before tissue reflection. Consider the anatomy of the bone at each score mark, and determine whether it would be more ideal if the mark were moved up to 2 mm in any direction. Usually, this amount of deviation will not affect the restorative procedure. If desired, rescore the ridge at a more appropriate point nearby.

An imperfection, undercut area, or lack of width may be encountered precisely at the location of a score mark. If so, this site is best avoided. If relocation is considered, be sure not to approach too closely to the mental foramen or a sinus, and try to stay positioned beneath the anticipated final location of the band of attached gingiva if doing so will not compromise esthetics or occlusion.



FIG. 10-21 ■ Widened ridge crest marked for planned osteotomies.

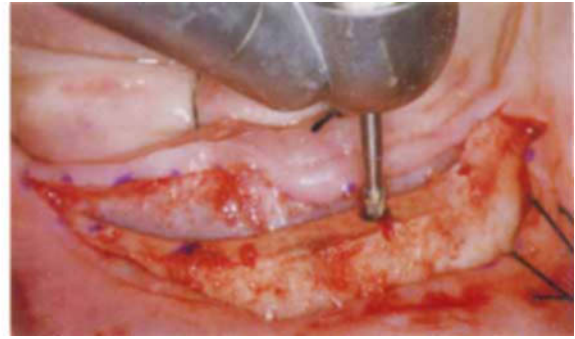


FIG. 10-23 ■ Establish labio-lingual and mesio-distal axial inclination of osteotomies.



FIG. 10-22 ■ Twist drill, pilot drills, counterbore, and thread-former for osteotomy preparation.

Prepare Implant Osteotomy

Basic Considerations of Osteotomy Drilling. All osteotomy drilling is performed with copious coolant to control temperature. A high-quality, low-speed, high-torque drilling unit with control of speed and coolant is required. Following the drilling speed protocols is important to ensure that bone will not be damaged during osteotomy preparation.^{6,7} Excessive pressure must be avoided. Intermittent drilling is a necessity. Frequent drill withdrawal followed by lavage and careful suctioning to remove unwanted bone chips from the partially prepared site is advised. Place the suction tip at the edge of, but not directly over, the osteotomy.

The osteotomy is formed using a series of **twist drills**, pilot drills, depth drills, a counterbore, and a threadformer (Fig. 10-22). The threadformer creates a threaded pathway of controlled width and depth to guide implant placement in the osteotomy.

Each point of initial entry is indicated by a score mark placed on the alveolar ridge, as previously described. These score marks also act to stabilize the drill as penetration of the bone begins.

The pilot drill does not create the final shape of the osteotomy. Nonetheless, it is best to establish as accurately as

possible the labio-lingual and mesio-distal angle at which the drill will be held as it penetrates bone (Fig. 10-23).

Every effort is made to be accurate at every step of the procedure to obviate the need for corrections as one proceeds. Visualize the ideal position of the long axis of the implant within bone. Consider the relative benefits of bisecting the cortical plates to take best advantage of available bone and slightly altering this position in favor of coming as close to ideal parallelism as possible for restorative purposes.

In cases such as the teaching case, in which a series of implants is to be inserted, it is best to complete each step for each osteotomy before moving on to the next step. Start at the posterior site, and keep the field of operation as clear as possible as the implants are successively treated from the posterior to the anterior on each side of the midline. Insert a **paralleling pin** when each pilot drill pathway is enlarged and completed.

The paralleling pin will protrude to act as a further guide in angling the pilot drill for the adjacent osteotomy preparation.

To prepare the final osteotomies, the 3.25-mm depth drill and 4.1-mm counterbore are used. Proper use of these drills is a key to success. The 3.25-mm implant depth drill is equal to the inside diameter of the implant, and the 4.1-mm counterbore provides space for the neck, to promote early healing in an immobile environment. During drilling, it is counterproductive to move the contra angle in any way that will enlarge the osteotomy.

Before entering the pathway created using the pilot drills, again mentally establish the ideal axis of drilling. Keep it in mind at all times, and hold steady as the implant depth drills are intermittently used until the final depth is reached. A fixed axis of entry, controlled pressure at recommended speeds, copious coolant, intermittent drilling, and frequent lavage are desired.



FIG. 10-24 ■ Use of pilot drill held in long axis of planned osteotomy.

Pilot Depth Drill Pathway. Review the preoperative assessment of how many millimeters of bone exist beyond the depth of the planned implant to the cortical bone at the inferior border of the mandible. Consider the width of the ridge at the planned point of first entry, which is the most posterior planned osteotomy site. If there are a few millimeters of excess available bone depth and it is desirable to obtain more width, the crest can be ramped now by 2 to 3 mm using a tapered carbide bur at 2000 to 3000 revolutions per minute (rpm). In mainstream cases this may not be required.

Although this is common practice, it is best not to have to ramp down the ridge crest to avoid early resorption to the greatest extent possible. Do so only if it offers a clear benefit to the case at hand.

If the score mark in the ridge crest needs to be refreshed or deepened, do so now with a No. 6 bur at a speed of 1800 to 2000 rpm. Then place the pilot depth drill in position, and drill at no more than 1000 rpm to the desired depth to create a pathway for its enlarging successor (Fig. 10-24). Cleanse the area. Insert a paralleling pin for guidance as this step is completed for each osteotomy (Fig. 10-25).

Drilling is a strictly controlled procedure. The parallel-sided pilot depth drill diameter for use with the 3.8/4.1-mm diameter teaching case implants is 3.25 mm. It is clearly marked at depth levels of 12, 14, 16, and 18 mm to indicate to the practitioner the depth at every moment of drilling. The depth drill diameter of 3.25 mm is equal to the minor diameter of the 3.8-mm threaded implant body. This allows for either self-tapping of the implant into the site or pretapping with the thread-former to thread the osteotomy walls precisely. Many practitioners prefer to start penetration using a 2.0-mm pilot depth drill, then a 2.7-mm pilot depth drill, and finally a 3.25-mm depth drill to increase successively the osteotomy diameter until the appropriate diameter and depth are reached.

The osteotomy is now started using a 1.5-mm twist drill, followed by pilot depth drills of 2.0 mm and 2.7 mm, and finally a 3.25-mm depth drill. Do not exceed 1000 rpm, and constantly supply coolant when drilling.

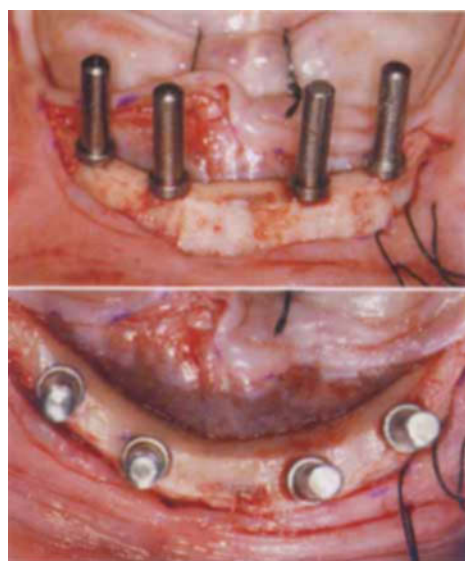


FIG. 10-25 ■ Paralleling pins confirm parallelism among implants.

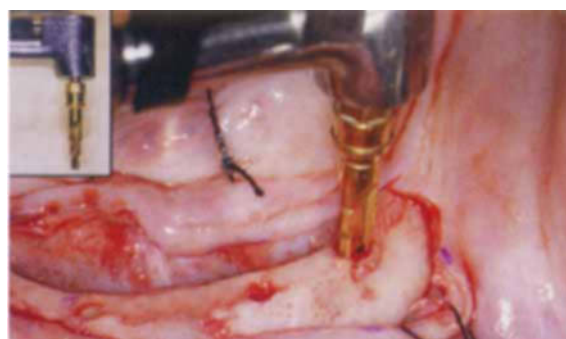


FIG. 10-26 ■ Use of counterbore to size coronal portion of osteotomy properly.

In properly diagnosed and executed cases, encroaching on landmarks should not be a concern.

Completion of the Implant Osteotomy. Each implant configuration has a corresponding counterbore (Fig. 10-26) and threadformer (Fig. 10-27). The 3.8-mm diameter, 12-mm depth implant bur corresponds with the dimensions of the implants used in the teaching case. The bur is carefully placed and angled at the opening of the pathway created using the pilot depth drills, and each osteotomy is completed at a speed of 800 to 1000 rpm with constant coolant. After penetration to the final depth, cleanse the area. The threadformer is used when the bone is dense, making self-tapping into the bone difficult. This usually is the case in the anterior mandible. The osteotomy now is ready to receive the corresponding implant try-in to verify correctness before implant seating.

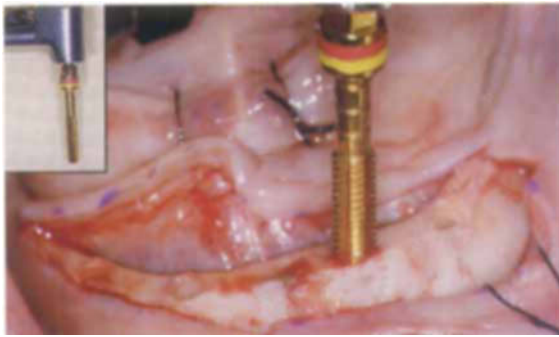


FIG. 10-27 ■ Use of threadformer to tap bone.

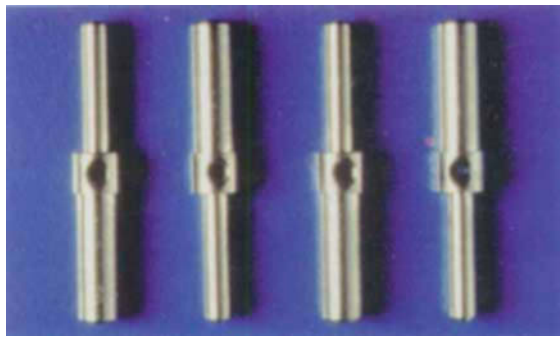


FIG. 10-28 ■ Implant try-ins. Wide half is used to check completed osteotomy, and narrow half is used for paralleling during use of pilot drill.

Note that the speed of drilling using the counterbore and threadformer is controlled. Every effort is made to control heat production. Intermittent drilling, low pressure, and repeated cleansing are always recommended. Reverse is necessary to remove the threadformer carefully from the osteotomy. The threadformer cannot be pulled out, or the threads will be stripped.

Evaluate and Test Prepared Osteotomy

A smooth-sided implant try-in coordinated with the dimensions of the selected implant configuration is used to check for adequate depth of the prepared osteotomy. This implant try-in has a coronal depth gauge projection for ease of handling and checking the osteotomy. Each implant configuration has a coordinated implant try-in (Fig. 10-28). The portion with the narrower diameter on the opposite end of the try-in serves as a paralleling pin for use with a corresponding depth drill, as shown in Fig. 10-25. With gentle finger pressure, insert the gauge into the osteotomy. Check that all points of the coronal edge are at or below the crest of bone. If this is the case, the site is acceptable, and one may proceed. The implant try-in may indicate an unacceptable site in one of two ways. If the implant try-in does not seat all the way, such that its



FIG. 10-29 ■ Ratcheting immediate transfer coping/implant assembly into position.

coronal edge is not below the crest of bone, then the osteotomy is too shallow. In this case, deepen the osteotomy to allow the implant try-in to seat properly. In such cases, first confirm that clearance is adequate beyond the depth of the osteotomy to the nearest landmark. If the implant try-in seats all the way but does not exhibit a firm fit with the walls of the osteotomy, then a backup configuration of the next largest diameter can be used if available bone width is sufficient. The appropriate coordinated final depth bur, counterbore, and threadformer are used with extreme care to avoid the formation of an oversized osteotomy. In the presence of a significant volume of relatively soft cancellous bone, avoid use of the threadformer in favor of self-tapping to seat the implant to its final position without overenlarging the osteotomy.

Every step of the insertion procedure is carefully performed and checked. In this way, any problems can be corrected immediately, ensuring that subsequent steps can proceed successfully.

Final Seating of the Implant

Carefully transfer the implant to place it into the prepared osteotomy. When the implant is removed from its sterile packaging, deliver it directly to the osteotomy by holding the attached immediate impression transfer coping. Do not bring the implant into contact with gauze or any surface other than that of its original packaging. Immediately following placement into the prepared osteotomy, ratchet the implant into its final position, at or below the crest of bone. Cleanse the area. The implant insertion is complete. The immediate impression transfer coping is still in position (Fig. 10-29).

If because of anatomic irregularity the coronal edge of the implant is not entirely below the ridge crest, ratchet again to reach the desired depth. If primary retention is insufficient, consider using a backup implant of the next greater diameter. Once the implant is firmly in position, do not remove it. Cleanse the area.



FIG. 10-30 ■ Mated immediate impression transfer copings in position for impressioning.

Insertion Visit Direct Bone Impressioning

The object at this step of the procedure is to simplify and expedite the restorative phase of the case. Increasing professional acceptance of this technique reinforces our belief that it represents a significant improvement in root form prosthodontics. The necessary direct bone impressions and bite registrations are taken now, to provide the laboratory with the information it requires to fabricate the custom abutment clip bar assembly that will be used for retaining the final overdenture.

Performing this step of the procedure now significantly simplifies the restorative process. During the 4 to 6 months of healing following implant insertion, the laboratory will fabricate the final attachment mechanism. Therefore, when the healing collars are removed (if the semi-submerged healing protocol is followed), or when cover screws are removed following surgical exposure (if the submerged healing protocol is followed), the splinted custom abutment clip bar assembly can be placed into position. The custom abutments will also act as healing collars as gingival tissue conforms around them.

Immediate Impression Transfer Copings. Immediate impression transfer copings are supplied fastened to each implant delivered from the manufacturer (Fig. 10-30). In the teaching case, the implants are 3.8/4.1 mm in diameter, mated to their supplied transfer copings as delivered. When the implant is seated, the transfer copings are automatically in position for the following procedure. Cleanse the area.

The case is now ready for direct bone impressioning.

Insertion Visit Immediate Direct Bone Impressioning. To supply the laboratory with the information it needs to pour an accurate model, a direct bone impression is now taken with the immediate impression transfer copings in position.⁸ This impression may be taken with any accepted elastic impression material, preferably the type

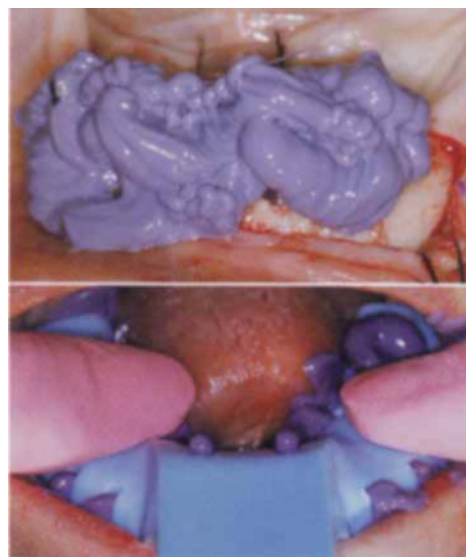


FIG. 10-31 ■ Immediate direct bone impressioning. Placing impression material (A) and seating impression tray (B).

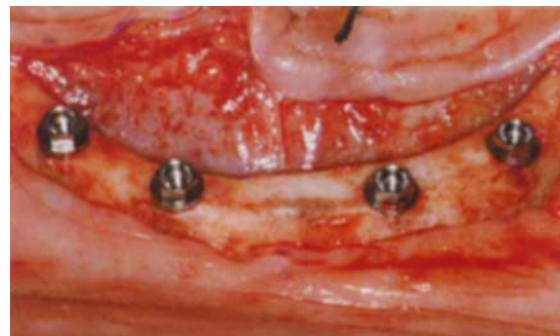


FIG. 10-32 ■ Seated implants after removal of immediate impression transfer copings.

one commonly uses for conventional crown and bridge techniques. The impression is taken with an open tray to allow the transfer coping to project through the impression material (Fig. 10-31). If excess impression material covers the end of a transfer coping, trim it to expose the screw that secures the transfer coping into position after the impression material sets. A closed tray may be used for cases in which implants are sufficiently parallel to each other to permit ease of removal of the impression.

Taking the impression with an open tray allows direct access to the screws that hold the transfer copings correctly positioned against each implant.

Remove the four **transfer coping attachment screws**, and then remove the impression from the oral cavity. When the transfer coping attachment screws have been removed, regardless of the degree of parallelism or lack thereof of the inserted implants, the impression can be easily removed (Fig. 10-32). Often in mainstream cases, the

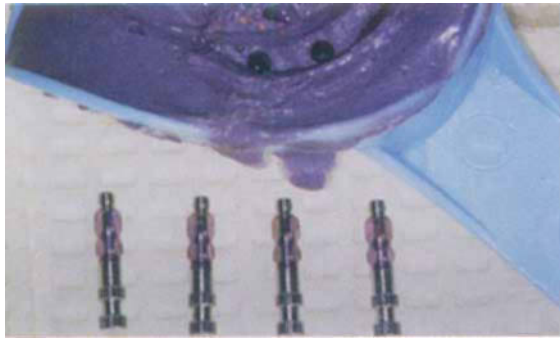


FIG. 10-33 ■ Immediate impression transfer copings mated to coordinated implant analogs.



FIG. 10-34 ■ Transfer copings and analogs seated in immediate direct bone impression.

immediate impression transfer copings are parallel to each other because the implants were ideally inserted. In such cases, closed-tray direct bone impressions can be taken and removed, after which the immediate impression transfer copings are removed intraorally.

To maintain sterility, dedicate an impression material setup exclusively to this procedure. After the impression has been taken and removed, be sure to cleanse the area completely. No residual impression material may remain against bone or any portion of the implant.

Cleanse the transfer coping attachment screws. Place them through the transfer copings held securely within the impression material, and screw each one down against its carefully positioned coordinated implant analog (Fig. 10-33).

The impression with this assembly is delivered to the laboratory with the transfer copings attached to four coordinated 3.8/4.1-mm externally hexed implant analogs. The laboratory will pour an accurate model (Fig. 10-34) for the fabrication of the final custom abutment clip bar assembly.

Insert Titanium Cover Screws or Healing Collars

If semi-submerged healing is desired, a healing collar of a diameter that corresponds to that of the implant is se-

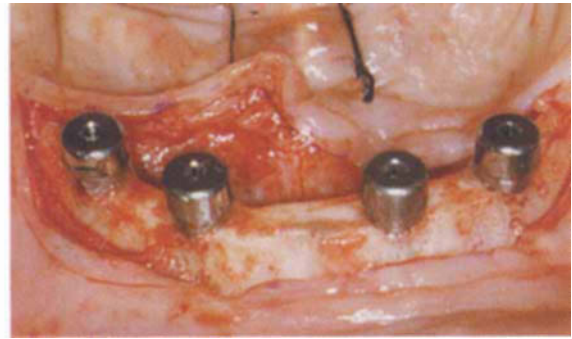


FIG. 10-35 ■ Healing collars in position on implant body before suturing.

lected. In the teaching case, the appropriate diameter is 4.1 mm. If the semi-submerged healing option had been used in the teaching case, straight healing collars of appropriate height would have been chosen (Fig. 10-35). They are supplied in various heights to match any thickness of the gingival crest. The seated healing collar should be flush with the gingival crest, or up to 1 mm above it after suturing. The selected healing collars are seated firmly in the same manner as titanium cover screws.

If submerged healing is desired, titanium cover screws are placed and fastened using the appropriate driver. The driver is selected to ensure adequate manipulation for tightening to achieve a secure fit.

Note the versatility of this system. Healing collars obviate the need for surgical implant exposure after 4 to 6 months, but they must not be in function during the healing period. Provisional removable dentures must be fully relieved to prevent functional forces of any kind from passing through the healing collars during healing.

Perform Interarch Occlusal Registrations

The original study model of the opposite arch is included in the delivery to the laboratory. If one wishes to retain this model, it can be duplicated, or one can reimpression the patient and pour another model. Following direct bone impressing, removal of the transfer copings, and insertion of either appropriate healing collars or cover screws, an interarch occlusal registration is recorded before closure. After removing the transfer copings from the implant analogs on the laboratory model, this bite is used to relate the opposing models for articulation. The articulated models then are used for fabrication of the splinted custom abutment clip bar assembly.

It is preferred that bite registrations and counter-model procedures be performed just as they are in one's conventional office routine. When these procedures are complete, the area is again cleansed thoroughly.

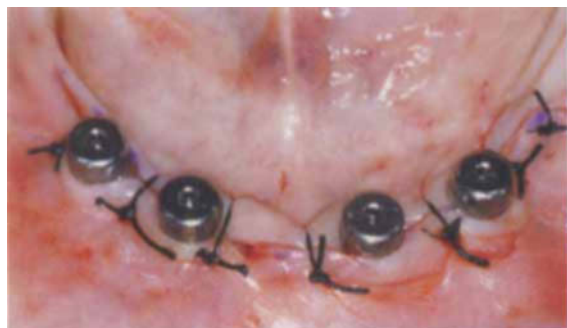


FIG. 10-36 ■ Healing collars following suturing. Ideal gingival relationship.

Treat Soft Tissue Postinsertion

If required because of the presence of flabby tissue over the incision site preoperatively, or in the case of excessively thick maxillary gingiva, remove any excess tissue that will interfere with coapting the flaps, decrease flap thickness if required, reduce flabby tissue, and correct tissue bunching according to the procedures and principles described in Chapter 9.

Whether or not these **gingival flap plastic surgery** procedures are required, in the case of semi-submerged implants with healing collars, tissue punch to remove any tissue that bunches around the collar upon coapting, again according to the procedures described in Chapter 9. When the soft tissue is ready for suturing, take a periapical radiograph for the patient record.

Final Closure—Suturing

Suture according to the principles and procedures described in Chapter 9 (Fig. 10-36).

Select Shade

As discussed in Chapter 9, select the shade to be used in the restoration.

Provisional Removable Prosthesis

If a provisional prosthesis is required, it must be fitted carefully. If an existing removable complete denture is used as the provisional restoration, reduce its entire tissue surface over the area of treatment, apply a soft relined material, seat, and trim and adjust the borders. Then check the occlusion and adjust it to be light, in case the patient tends to clench or grind. Next, relieve the tissue areas immediately over each healing collar of semi-submerged implants, or the gingiva over each submerged implant, such that when seated there is at least 1 mm of clearance.

To ensure osteointegration, no pressure of any kind should be applied to a healing root form implant. Dietary constraints also help to promote afunctional healing.

BOX 10-4 ■ VISIT 2, WEEK 1: SUTURE REMOVAL AND INTERIM EVALUATION

Perform general evaluation
Remove sutures
Evaluate soft-tissue healing
Check and adjust removable prosthesis as required

Postinsertion Home Care Instruction

As discussed in Chapter 9, advise the patient about possible effects resulting from the trauma of the surgery, and prescribe comfort medication and prophylactic medication against infection. The patient must also be instructed in postoperative cleanliness and in maintaining a soft diet to ensure that excessive function of the implant will not interfere with tissue integration.

Postinsertion Follow-Up Visit

As described in Chapter 9, a postinsertion follow-up visit is scheduled for 7 to 10 days after insertion (Box 10-4) to perform a general examination, remove the sutures, evaluate soft-tissue healing, and check and adjust the fit of the provisional removable prosthesis.

Postinsertion General Considerations

In cases of normal healing, the implant exposure appointment is usually made 4 months after suture removal in the mandible and 6 months after suture removal in the maxilla.

These healing periods allow for direct bone ingrowth among the implant threads and bone apposition to the interface, which is the point of the functional osteointegration planned for in the case sequencing. The overlying soft tissues will heal within 1 month.

Following 4 to 6 months of healing, the patient is scheduled for implant exposure, either by removing healing collars or reflecting tissue to remove titanium cover screws. The splinted custom abutment clip bar assembly is affixed to the implants, and the provisional denture is reamed out to relieve the area over the attachment assembly.

VISITS 3 TO 6: OVERDENTURE FABRICATION

General Considerations

During the months when the peri-implant tissues are healing afunctionally, the patient visits the office several times for fabrication of the overdenture (Box 10-5). The soft tissues overlying the submerged implants or around healing collars of semi-submerged implants are completely



FIG. 10-37 ■ Completed stage one overdenture.

BOX 10-5 ■ VISITS 3 TO 6, WEEKS 3 TO 12: OVERDENTURE FABRICATION

Take preliminary impression
Take master impression
Counter model and interarch occlusal registration
Select shade
Select teeth
Try in overdenture
Prepare retention mechanism clearance within overdenture
Complete overdenture

healed within 1 month. During the remainder of the 4- to 6-month healing period, stage one of the fabrication of the final overdenture is accomplished.

Fabrication of the Overdenture

The practitioner now fabricates a complete mandibular removable denture exactly as one would if it were not implant supported. Preliminary impressions, master impressions, and interocclusal bite registrations are taken. Shade is rechecked. Tooth molds are selected. The master model is mounted in proper relation to its counter on one's articulator of choice. A setup of the selected teeth, in wax, is tried in at a patient visit. Flange extension, vertical, and centric are checked. Shade is verified, and esthetics confirmed or altered as required. Attention is paid to the tissue area over the healing implants to ensure that clearance is sufficient to insert the splinted custom abutment clip bar assembly into the denture during stage two procedures. The required number of patient visits to accomplish this varies office by office and patient by patient. However, several months are available to accomplish this at leisure while bone is healing around the implant. When all is as desired, the case is sent back to the laboratory for processing. Before processing, the laboratory reams out the tissue surface of the denture wax-up in the area that will be occupied by the splinted custom abutment clip bar assembly when it is attached to the implants. Stage one is completed (Fig. 10-37). The overdenture is stored for use after implant exposure.

BOX 10-6 ■ VISIT 7, WEEK 16: IMPLANT EXPOSURE AND OVERDENTURE RETENTION MECHANISM FIXATION

Confirm use of prophylactic antibiotic
Set up instrumentation
Administer anesthetic
Identify implant locations, if submerged
Expose implants or remove healing collars
Perform trial seating of overdenture retention mechanism
Fix overdenture retention mechanism
Suture, if required
Seat provisional prosthesis
Provide home care instruction
Schedule follow-up visit

VISIT 7: IMPLANT EXPOSURE AND OVERDENTURE RETENTION MECHANISM FIXATION

The steps that are performed for implant exposure and fixation of the overdenture retention mechanism are shown in Box 10-6.

Preoperative Medication

When the submerged healing protocol is followed, gingival tissue overlying the implants must be reflected only to the extent required for exposure of the cover screws. This is a minor procedure. Most practitioners do not premedicate the patient, unless it is advisable for peripheral medical reasons.

If premedication is indicated, follow the same guidelines as for premedication before implant insertion. Edema is almost never observed after implant exposure.

Instrumentation Setup— The Armamentarium

The tray setup for surgical implant exposure is far simpler than that for implant insertion. Only one tray is required. A scalpel, periosteal elevator, cover screw remover, Noyes scissors, tissue holder forceps, hemostatic agent, needle holder, 3-0 sutures, mirror, and explorer are the essentials.

Any other instruments of personal preference that help facilitate treatment should also be included.

Preoperative Tissue Preparation

The same regimen performed before implant insertion is repeated, including thorough inspection of the oral cavity to locate and remove any residual food particles, thorough lavage, and application of a topical bactericidal agent.

Local Anesthetic, Promotion of Comfort, and Control of Bleeding

Except in the rare cases in which the patient's history or medical condition indicates that special considerations exist, a local anesthetic containing vasoconstrictor is sufficient. Only infiltration is required. Following administration of a topical anesthetic, the buccal fold and ridge crest are infiltrated in the area of the submerged implants.

Try to deposit the anesthetic along the crest directly over each implant. As a guide, use of the implant positioning stent that aided osteotomy preparation may help.

Recording of Implant Locations

If the submerged healing protocol has been followed, place the implant positioning stent and mark the probable position of each implant with an indelible tissue marker. Remove the stent, and carefully palpate the area to identify the perimeter of each implant. Mark each location if it differs from the mark made using the stent.

If the outline cannot be felt accurately, it may be necessary to probe through the tissue using a sharp explorer, at least for initial orientation.

Implant Exposure

If the semi-submerged healing protocol was followed, the 0.05-mm hex driver is seated on the distal implant's healing collar. Carefully remove the healing collar with as little torque as possible. Remove all four healing collars in this manner.

Little or no bleeding should be observed at this time. One may observe healed gingival cuffs following the contours of the healing collars.

In cases that follow the submerged healing protocol, following the administration of local anesthetic, incise the tissue along the incision line initially created for insertion, and reflect the flaps to expose the implants and their cover screws.

Inspect and cleanse the area all around the implant periphery. Control bleeding with direct pressure. If necessary, further infiltrate with local anesthetic containing vasoconstrictor.

Removal of Cover Screws/Healing Collars

Select an appropriate remover, engage it to the cover screw or healing collar of the most posterior implant, and remove it as gently as possible. Cleanse the area. Repeat the

process for each cover screw or healing collar, proceeding from the most posterior implant to the most anterior.

Again, carefully inspect the area. Remove tissue tags, if present, with a Noyes scissors or other suitable instrument. Cleanse the area again.

Trial Seating of Splinted Custom Abutment Clip Bar Assembly

The 4.1-mm diameter overdenture conical abutments would have been used if prefabricated abutments had been used in the teaching case. They are supplied with polished collars that are 1.5, 2.5, 3.5, and 4.5 mm in height. In the teaching case, custom-made overdenture abutments are fabricated and splinted into a clip bar assembly. Each overdenture abutment is designed to be fixed to its underlying implant with coronal screws supplied by the manufacturer. Following implant insertion, the splinted custom abutment clip bar assembly is fastened into position with the appropriate driver by setting the four coronal screws.

Before doing anything else, radiographically and visually check the margins to ensure that the abutments are fully seated. This is critical, and avoids undue complications. Also check margins for accuracy.

The immediate direct bone impression is very accurate. Although many practitioners try in the appropriate abutments first, many fabricate a custom abutment clip bar assembly on the immediate direct bone impression master model. In this option, the laboratory waxes up its own equivalent of conical abutments, adds retention bars for clips, and casts the splinted custom abutment clip bar assembly. The completed splint is tried in and fastened (Fig. 10-38). The teaching case is approached in this manner. Again, it is critical to radiographically and visually check seating and margins for accuracy (Fig. 10-39).

This technique saves valuable time and effort, and materially reduces trauma to the patient.

Fixation of Splinted Custom Abutment Clip Bar Assembly

Following trial seating and radiographic and clinical confirmation of full seating, margins, and adaptation, the splinted custom abutment clip bar assembly is fixed into position with coronal screws, as shown in Fig. 10-38.

One advantage of this method is that it allows for removal of the entire splinted custom abutment clip bar assembly should complications of any nature occur.

Be sure to cleanse the pergingival site down to the junction between each custom abutment and the implant platform.



FIG. 10-38 ■ Try-in of a splinted custom abutment clip bar assembly.

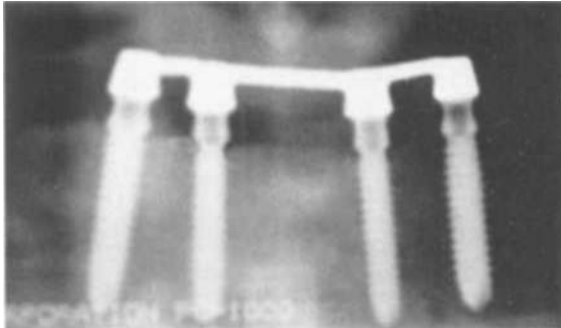


FIG. 10-39 ■ Radiographic check of abutment seating and splinted clip bar assembly.



FIG. 10-40 ■ Relieved provisional denture with soft reline to promote afunctional healing.

Tissue Contouring/Suturing (for Submerged Cases)

If the semi-submerged healing protocol was followed, no tissue contouring or suturing is required at this time. The treatment sequencing then continues with the section that follows on adapting the overdenture to the attachment/bar mechanism.

If the submerged healing protocol was followed, the flaps are placed against the splinted custom abutments. A tissue punch is used to contour the tissue around the custom abutments in the same way as described for contouring the tissue around the healing collar for the semi-submerged healing protocol during the original implant insertion visit. Suturing is now performed as described earlier.

Provisional Removable Denture

If the submerged healing protocol was followed, after suturing has been completed, it is advisable to adapt and

then replace the original provisional removable denture. The patient is accustomed to it. In the tissue areas of the denture directly over the now protruding splinted custom abutment clip bar assembly, a recess must be prepared into the provisional overdenture so that following seating there is no contact anywhere (Fig. 10-40).

Immediate Postexposure Home Care Instructions

Trauma. The implant exposure procedure is almost never traumatic. Postoperative edema is seldom observed. Starting on the second day, rinsing with a mild salt and water solution or with chlorhexidine is advised.

Prophylactic Antibiotic Medication. Unless indicated for medical reasons, prophylactic antibiotic medication is not necessary.

Comfort Medication. Comfort medication usually is required. A prescription for ibuprofen (Motrin) 400 mg, 6 tablets, may be given to promote patient confidence.

Cleanliness. During early healing of the soft tissues after implant exposure and assembly fixation, it is advisable not to floss the assembly, since this can disrupt delicate healing. Gentle lavage or rinsing is advised.

Diet/Function. The patient is advised to eat carefully. A soft diet is recommended.

Postexposure Follow-Up Visit. The patient is scheduled for a follow-up visit 10 to 14 days after the implant exposure visit. Healing and the provisional restoration are checked. In the case of submerged healing, the sutures are removed at this time.

If healing is complete, the restorative procedure may be started immediately. If healing is not yet complete, the restorative procedure is delayed for another 1 to 2 weeks.

VISITS 8 TO 10: ADAPTING THE OVERDENTURE TO THE RETENTION MECHANISM, AND CASE COMPLETION

The steps that are performed to adapt the overdenture to the retention mechanism are shown in Box 10-7.

Suture Removal

Cleanse the area. Sutures are carefully removed with the aid of a suture or Noyes scissors. Tincture of benzoin or any other accepted medication can be applied to the tissues.

If the submerged healing option was chosen, following implant exposure and fixation of the splinted custom abutment clip bar assembly, tissue contouring and suturing are performed at this time.

Overdenture Clip Bar Retention Mechanisms

For the teaching case, a splinted custom abutment clip bar assembly was chosen for overdenture retention. Use of this system is straightforward and has been proven to be efficient and adjustable. Other systems are also available (Fig. 10-41). We advise that one's first several cases be fabricated using the splinted custom abutment clip bar assembly for overdenture retention used in the teaching case.

Master Model. The laboratory has reamed the overdenture to clear the splinted custom abutment clip bar assembly. A master model must be poured, on which the overdenture can be seated in correct relationship to the splinted custom abutment clip bar assembly so that the selected retention clips over the bar can be correctly related to it. The retention clips are seated on the bar, and undercuts under the bar are blocked out.

Fill the reamed out area within the overdenture with a firm elastic impression material after the required adhesive has been applied. Seat the overdenture over the clip attachments seated on the bar, and have the patient bite down in centric occlusion and maintain pressure until the material sets.



FIG. 10-41 ■ Alternative ball attachment retention mechanism.

BOX 10-7 ■ VISITS 8 TO 10, WEEKS 17 TO 18: ADAPTING THE OVERDENTURE TO THE RETENTION MECHANISM AND CASE COMPLETION

Remove sutures, if necessary
Seat retention clips on clip bar assembly
Take impression for removal of clips in overdenture
Send impression to laboratory to incorporate clips into overdenture
Seat completed overdenture for patient

It is important to have the patient bite firmly until the elastic impression material has set. This will allow the overdenture to be seated against the tissues without undue stress or torque on the splinted custom abutment clip retention bar and the underlying implants when the patient is applying functional force to the overdenture.

Remove the overdenture. Remove the undercut blocking material, and cleanse around the splinted custom abutment clip bar assembly. Inspect the impression area for completeness. Remove the retention clips from the bar and seat them into the elastic impression. Send the impression to the laboratory with instructions to pour a master model against the enclosed overdenture, process the case, and incorporate the clips into their proper recorded positions (Fig. 10-42).

Laboratory Technique for Attaching Clips to New or Existing Overdentures. The laboratory will follow the procedure shown in Box 10-8 to attach clips to the new or existing overdentures.

Case Completion

When the laboratory returns the stage two completed overdenture, usually in a day or two, insert it for the patient. The case is complete.

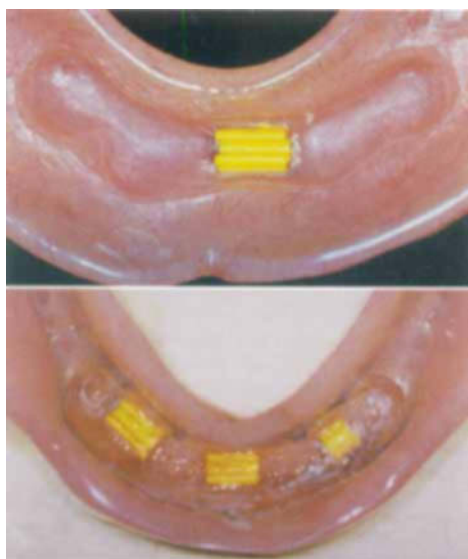


FIG. 10-42 ■ Variations of clip attachment designs for clip bar assemblies.

BOX 10-8 ■ LABORATORY PROCEDURE TO ATTACH CLIPS TO NEW OR EXISTING OVERDENTURE

Place overdenture retention clips into sites recorded in reline impression
 Pour model, allow to set, and trim
 Perform separation (retention clips remain on model)
 Remove impression material and clean overdenture
 Carefully cover occlusal side of each clip with a thin layer of wax (0.5 to 1 mm) to allow vertical displacement of denture while seating and during mastication
 Cover model with two coats of separating medium, rinse lightly, and allow to dry
 Seat denture on model to ensure that enough of tissue surface has been relieved
 Mix cold cure reline material according to manufacturer's instructions after brushing a thin layer of monomer into the relieved area in the overdenture
 Reline overdenture on model using conventional technique
 Incorporate retention clips within the overdenture
 Finish and polish
 Check and relieve as necessary around clips to ensure correct path of insertion

AFTERCARE AND MAINTENANCE Regimen for Increasing Function

In the case of osseointegrated implants, healing is already advanced by the time the final restorations are placed. The soft and hard tissues around the implant and its components can easily withstand a regimen of increasing function over 2 to 4 weeks, until full function is reached.

Patients are advised to monitor their function, and if any discomfort is experienced during mastication, to faith-

fully and without fail note the area of concern and return to the office for adjustments and evaluation. Such occurrences are rare. Most often, the period of increasing to full function is asymptomatic.

As is discussed in Chapter 9, professional and home maintenance must be performed regularly and diligently to avoid complications.

COMPLICATING AND ATYPICAL CONDITIONS

Common Complicating and Atypical Conditions

The complicating and atypical conditions that are common to the treatment procedures using any of the abutment-providing implant modalities, as discussed in Chapter 9, are all applicable here. These include questionable adequacy of ridge width, minimal width of attached gingiva, frayed or torn flaps, excessive bleeding, retained root tip, presence of a cyst or granulomatous tissue, unusual variation in ridge height and/or contours, labial or lingual osseous perforation during osteotomy preparation, fracture of the labial or lingual osteotomy wall, friable tissue at suturing, excessive postoperative edema, and retained impression material. Each of these conditions is rare. Treating these complications properly is discussed in Chapter 9.

Extreme Angle Between Long Axis of Osteotomy and Parallelism Requirements for Conical or Custom-Fabricated Abutments

The existence of an extreme angle between the long axis of the osteotomy and parallelism requirements for conical or custom-fabricated abutments is rare, because conical abutments have a 25-degree taper that facilitates parallelism, and custom abutments are fabricated in parallelism. Therefore, the long axis of the osteotomy usually will be

at an acceptable angle. However, if the discrepancy between the angle required for overdenture restoration and that of the inserted implant is excessive, an alternative attachment system may have to be used. In the teaching case, custom fabricated abutments were used even though the angle of insertion of the implants would have permitted prosthodontic parallelism using prefabricated abutments. This was done because custom fabrication represents the simplest way to splint abutments using clip bars. In cases in which implants are not inserted at a suitable angle for prosthodontic parallelism, it is common to custom fabricate abutments.

VARIATIONS AND ALTERNATIVES

Submerged and Semi-Submerged Healing Options

The benefits and detriments of the submerged and semi-submerged healing options have been discussed throughout this chapter. Fully protected afunctional healing is of prime importance to achieve osseointegration, regardless of which protocol is used. The benefits of semi-submerged healing are worth having in cases in which no early provisional removable prosthesis is required for esthetics,⁹ or in cases that use a provisional prosthesis that can be accommodated with no less than 1-mm clearance directly over and around each healing collar. Whether the submerged or semi-submerged protocol is followed, the patient must be placed on a soft diet until the peri-implant tissues are sufficiently healed.

Sequencing of Transfer Coping Impressioning

The timing of transfer coping impressioning within the treatment protocol is not standard throughout the discipline. We advocate immediate direct bone impressioning on the day of implant insertion. The benefit is that the required implant abutments, provisional teeth, and even the final casting for the planned tooth restorations can be fabricated during the long period of initial bone healing required for root form implants. This reduces total elapsed treatment time, the number of patient visits, costs, and prosthodontic complexity. Many practitioners are unfamiliar with the concept, and fear displacement or even removal of the inserted implant as the elastic impression over the copings is removed. However, the fact that the coping fixation screws are removed intraorally from their transfer copings before the direct impression is removed

facilitates removal of the direct impression, with no possibility of implant disturbance.

If immediate impressioning is not desired, the transfer coping impression for fabrication of the prosthodontic master model can be taken on the day of implant exposure when healing collars are removed if the semi-submerged treatment protocol is followed, on the day of implant exposure if the submerged protocol is followed, or following healing and removal of healing collars that were placed on the day of implant exposure. In all such cases, adjustments to case sequencing are made accordingly.

Implant Insertion in New or Partially Healed Extraction Sites

For implant insertion into a new or partially healed extraction site to be considered mainstream, it must be possible to obliterate the tooth socket in forming the implant osteotomy, and infection or inflammation, if present, should be minor and under antibiotic treatment.

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11 Root Form Implants

Treatment of Posterior Partial Edentulism Diagnosed for a Fixed Prosthesis

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BENEFITS AND DESCRIPTION OF THE MODALITY AND SYSTEM USED IN THE TEACHING CASE

This chapter describes patient selection, diagnosis, treatment planning, and case sequencing for the treatment of posterior partial edentulism in the mandible using root form implants.

The most commonly used conventional threaded root form implants are approximately 4.0 mm in diameter and 10 to 12 mm in depth. The majority of cases that present with healed partially edentulous posterior alveolar ridges cannot accommodate this diameter and/or depth of implant. However, with the advent of the diffusion-bonded microsphere interface of the Innova Endopore root form system (Fig. 11-1), the range of applicability of the root form modality for this type of case is markedly expanded. The interconnecting porosities of this interface increase interface area to the extent that configurations two thirds the depth of conventional threaded root forms can be inserted to afford the same support. This is a significant benefit, not only because it increases the range of patients that can be offered mainstream treatment using the root form modality but also because the shallower implant can be inserted at an angle closer to that required for prosthodontic parallelism.^{1,2}

The Innova Endopore implant is supported by university-based research and clinical trials, some of which are presented in Chapter 8.

In totally edentulous arches with sufficient bone, a splinted series of osteointegrated root form implants may be used for sole support of a complete-arch 10- to 14-unit fixed bridge. Because of their relative complexity, such complete arch restorations using any implant modality are not considered mainstream. Root forms can also be used individually or splinted to support overdentures as shown in Chapter 10.

In mainstream cases of partial posterior edentulism, root form implants are suitable for individual support of

freestanding crowns, or may be splinted for combined support of an overlying prosthesis.

Mode of Tissue Integration

As a rule, root forms must osteointegrate to succeed in function long-term.³ Clinical trials have suggested that Innova Endopore implants may also be able to function with the osteopreservation mode of tissue integration (Fig. 11-2). Further research is being conducted to investigate the implications of this finding.⁴ In the teaching case presented in this chapter, the implants are case sequenced to achieve osteointegration. Because of biomechanical incompatibility, it is generally not recommended to join osteointegrated implants to natural co-abutments in mainstream cases.

Preparation for Treatment

Diagnosis and treatment planning is routine. Periapical radiographs, supplemented by panoramic radiographs if desired, are all that are required. Out-of-office radiography is not required for mainstream cases. Use of the root form modality in cases of posterior partial edentulism necessitates special consideration during the planning stages, because many ridges cannot accommodate the diameter and/or depth of these implants. Therefore, precise measurement and placement is required for proper function. A preinsertion positioning stent can be fabricated using a mounted cast to facilitate the procedure. Little else needs to be done during the planning stages, other than making a commitment to rigorously follow the treatment protocols outlined in this chapter.

Technique-Permissive Implant Insertion

The technique of inserting the implant is straightforward and easily mastered. Following the treatment protocol is

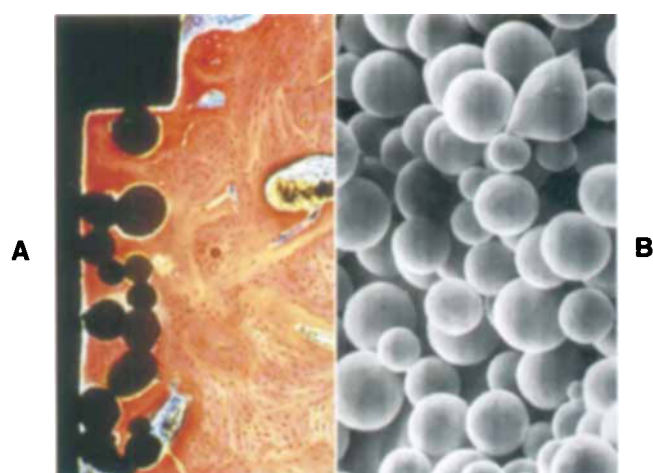


FIG. 11-1 ■ Diffusion-bonded microspheres with interconnecting porosities. Histology showing osteointegration (A) and scanning electron microscopy of microspheres (B).

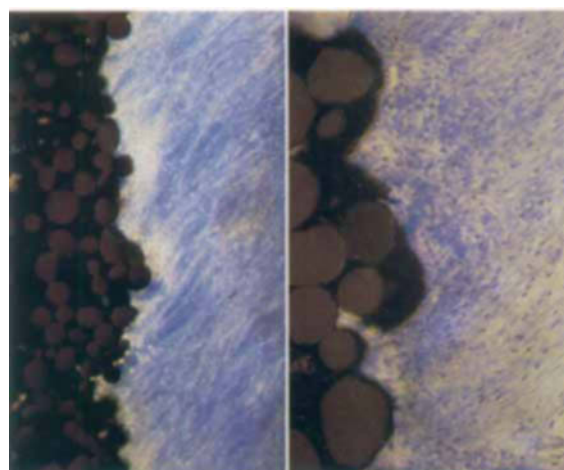


FIG. 11-2 ■ Microsphere interface: osteopreservation.

vital but not difficult. This protocol ensures that the desired mode of tissue integration is achieved as a result of appropriate case sequencing, and ensures sufficient support for the desired prosthodontic restoration.

Proven Long-Term Success/Survival Rates

More research has been devoted to the root form modality than any other implant modality. It is known to be safe and effective for its intended purpose of providing additional abutment support for prosthodontic restoration. Seminal studies related to this modality are presented and analyzed in Chapter 8.

Via clinical trials, some performed at the University of Toronto,¹ the safety and efficacy of the Innova Endopore system in particular have also been clinically validated. These studies are also presented in Chapter 8.

Unique Features

The diffusion-bonded microsphere interface with interconnecting porosities is unique to the Innova Endopore system.⁵ It is created by diffusion-bonding Ti6Al4V microspheres to the implant substrate, which is also composed of Ti6Al4V. Considerations related to diffusion-bonding are explained in detail in Chapter 4. The diffusion-bonding process homogenizes the microspheres into a solid unit both with each other and with the underlying implant substrate. This means that the metallurgy, whether in the middle of the implant substrate, in the middle of a microsphere, or across a “bridge” between two microspheres, is relatively uniform. The interface area is increased by such a substantial extent that the implants function successfully in configurations of approximately two thirds the depth of conventional threaded root forms. This expands the range of patients who can be considered candidates for mainstream root form treatment, increases the margin of safety in the engineering of the case, and allows placement of the implant at an angle closer to the prosthodontic ideal. These benefits are of particular relevance in posterior partially edentulous ridges, where depth of available bone often is insufficient for the placement of conventional threaded root forms.

The attachment components discussed in this chapter are simplified. Just a few of the many available attachment components are presented to promote ease of understanding, simplify prosthodontic protocols, and increase technique-permissiveness. A number of specialized components not used in this teaching case are available to accommodate other treatment planning requirements (Fig. 11-3).

Configuration and Nomenclature of the Implants Discussed in This Chapter

The implants discussed in this chapter are tapered cylinders with a diffusion-bonded microsphere interface, 4.1 mm in diameter, with a 1-mm smooth coronal region at the crest (Fig. 11-4). They are also supplied with a 2-mm smooth coronal region, which is not used in the teaching case. The implants used in the teaching case have the industry-standard external hex and internal threading. A cover screw is supplied by the manufacturer with each implant. To accommodate the various dimensions of available bone encountered in mainstream cases, the 3.5-mm diameter implant is supplied in a depth of 9 mm, and both the 4.1- and 5.0-mm diameter implants are supplied in depths of 7, 9, and 12 mm.

Prosthodontic components used to fabricate and seat the cement-retained crowns described in this chapter include transfer copings (straight or flared), implant analogs, prefabricated (straight, flared, or angled) or custom-fabricated hexed cementable abutments, and healing collars (Fig. 11-5). All of these components are supplied with appropriate retaining screws.

The prosthodontic components are available in diameters that correspond to each available implant diameter. Those used in the teaching case are 4.1 mm in diameter, to

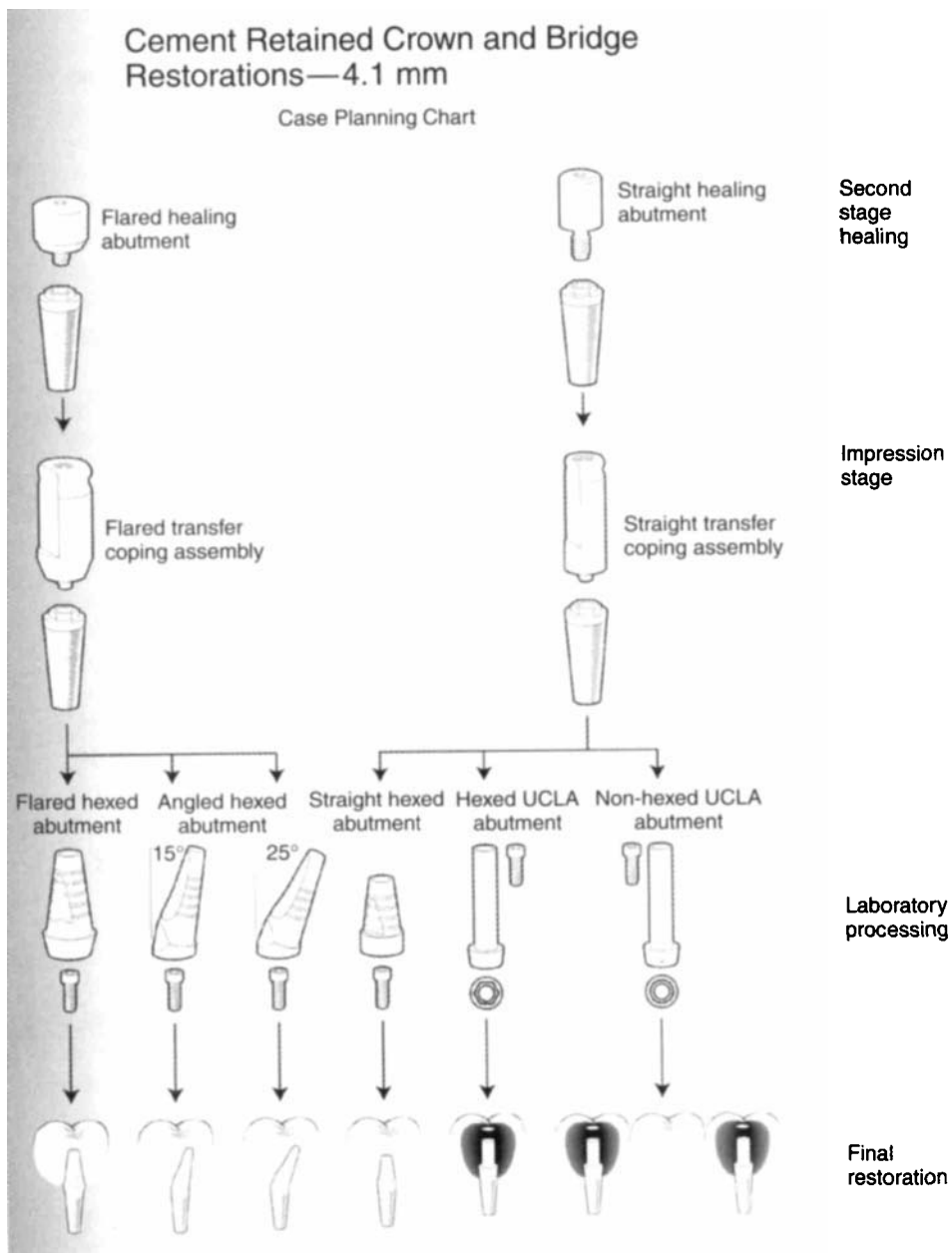


FIG. 11-3 ■ Flowchart of cement-retained prosthesis attachment mechanisms.

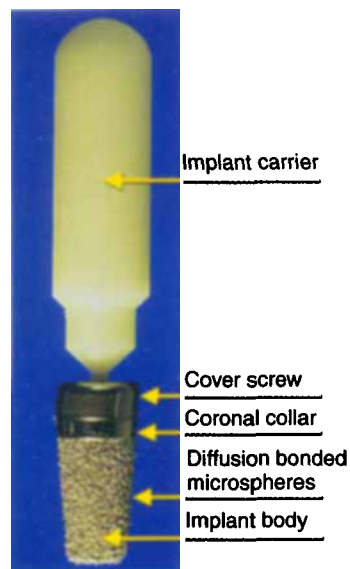


FIG. 11-4 ■ Innova Endopore implant.



FIG. 11-5 ■ Transfer coping (A), implant analog (B), cementable abutment (C), and healing collar (D).

correspond with the 4.1-mm diameter implants. The straight or flared transfer copings used are 11 mm in length, and the implant analog is 9 mm in length. Straight, hexed, cementable abutments are supplied 7 mm in length with a 1.5-mm collar, and 9 mm in length with a 3.5-mm collar. Flared, hexed, cementable abutments are supplied 10 mm in length with a 2-mm collar. Angled, hexed, cementable abutments are supplied at 15 and 25 degrees.

TYPICAL MAINSTREAM CASE—DIAGNOSIS, TREATMENT PLAN, AND END RESULTS

Case as Presented

Patient's Story. A typical mainstream case presents with posterior edentulism, either in the maxilla or mandible. The patient may have a removable, bilateral, free-end saddle partial denture, in which case one may hear complaints of complications associated with the natural abutments that have been clasped or fitted with semi-precision or precision attachments. The patient sometimes complains of odor, inability to chew food properly, poor esthetics, or gingival tissue complications. When no removable prosthesis exists, typical complaints are of a more significant inability to function; interference with speech patterns; sunken, hollow cheeks; and loss of facial height.

Clinical Appearance. Examination reveals a loose, unesthetic denture; poor hygiene; some loss of gingival height; and perhaps the initial stages of bone loss around abutment tooth roots. Facial contours may be compromised, and interocclusal height reduced. In mainstream cases, the edentulous portion of the alveolar ridge shows adequate bucco-lingual width and attached gingiva.

Radiographic Interpretation. The periapical radiograph reveals adequate osseous support around adjacent teeth, and sufficient length and depth of available bone to accommodate the insertion of enough implant abutment support to withstand anticipated functional loads long-



FIG. 11-6 ■ Example of marked borders of available bone.

term within physiologic limits of health. The landmarks and osseous borders are clearly identified on a periapical radiograph (Fig. 11-6).

Rejected Alternative Treatment Plans

The patient does not feel that adjustments to the existing removable partial denture or the fabrication of a new one would be satisfactory. The status quo is also clearly unacceptable, because the conditions about which the patient is complaining would remain and become more exacerbated over time. Therefore, implant treatment is indicated. A subperiosteal implant is not indicated in this case. There is too much alveolar bone, which would continue to resorb after placement of a subperiosteal, potentially causing substantial complications in the future. Plate/blade forms are not indicated, because the patient or the practitioner prefers not to treat the otherwise untouched adjacent teeth. Plate/blade form implants might have been considered if the teeth had previously been restored, treated endodontically, or required splinting for other reasons. Because the available bone present in any mainstream root form case will also accommodate treatment using

BOX 11-1 ■ VISIT-BY-VISIT TREATMENT OBJECTIVES

Preoperative procedures

Visit 1: Implant insertion

Visit 2, week 1: Suture removal

Visit 3, week 16: Implant exposure, direct bone impression, and interarch occlusal registration

Visit 4, week 17: Suture removal

Visit 5, week 18: Abutment cementation, placement of provisional crowns, and bisque-bake try-in

Visit 6, week 19: Cementation of completed crowns

plate/blade forms, considerations such as these help to dictate the choice of modality.

Accepted Treatment Plan—Visit-By-Visit Case Sequencing and Timing

The objectives of each of the treatment visits for the teaching case in this chapter are shown in Box 11-1. A basic understanding of the entire course of treatment is important, so that one can appreciate how each step presented in this chapter contributes to ultimate success.

Completed Case

Having the goal of treatment firmly in mind during each patient visit is important. Every procedure is directed toward successful completion of the case. Therefore, the end result is presented here, to help the reader understand how each step of treatment contributes to the final objective, and to convey the satisfaction and benefits of treatment both for the patient and practitioner.

Patient's Story. The treatment goals have been achieved. The patient's missing teeth have been replaced with nonremovable, comfortable, esthetic, implant-supported individual crowns that are efficient and easily cleaned, and that do not interfere with normal control of speech. The adjacent teeth were untouched. The patient is pleased and grateful.

Clinical Appearance. The esthetic result of the completed crowns closely resembles that of conventional fixed replacements. Flared healing collars, when indicated, can help improve esthetics. Ridge lapping can also be used for enhanced esthetics when appropriate. If the patient is amenable, bullet-shaped crowns can be used in nonesthetic areas. The clinical appearance indicates that the patient will have no trouble performing adequate home care.

Radiographic Interpretation. The postoperative panoramic radiograph reveals well-positioned implants (Fig. 11-7). Landmarks and borders surrounding the inserted implants have not been abridged or traumatized. Crowns exhibit correct marginal adaptation to the implants. The postoperative radiograph reveals harmony of

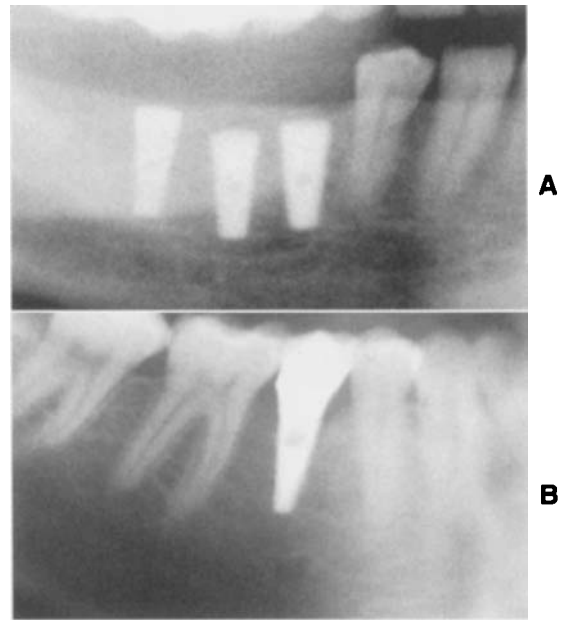


FIG. 11-7 ■ Inserted implants in teaching case (A) and an interdental completed case (B).

BOX 11-2 ■ PREOPERATIVE PROCEDURES

Quantify available bone

Select ideal implant configurations

Select implant abutment components

Fabricate implant positioning stent

Prescribe preoperative medication

the axial inclination of the implants, the result of careful planning and execution of treatment.

Microscopic Interpretation at the Interface. Following healing, light microscopy and scanning electron microscopy (SEM) reveal substantial bony ingrowth within the porosities of the microsphere interface, and excellent maintenance of crestal height of bone. The percentage of direct bone apposition and its distribution demonstrate an excellent example of successful osteointegration, as shown in Fig. 11-1.

PLANNING AND PROCEDURES BEFORE IMPLANT INSERTION

The steps that are performed before the implant insertion visit are shown in Box 11-2.

Quantify the Available Bone

Having determined that the osteointegration mode of tissue integration is indicated in this case, the next step is to quantify the available bone in the area targeted for implant insertion following the principles laid out in Chapters 3 and 9. To review briefly, use periapical radiographs to determine the length and depth of available bone between

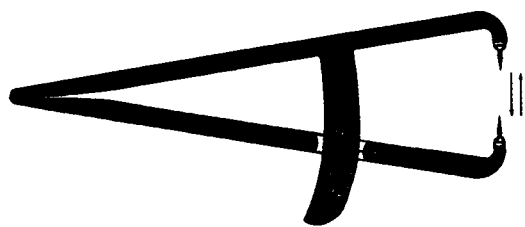


FIG. 11-8 ■ Ridge width-measuring caliper.

landmarks and borders. In cases of mandibular partial posterior edentulism, such as the teaching case in this chapter, recall that length of available bone is measured mesio-distally from the distal of the nearest tooth root to the ascending ramus in the mandible. Treatment of partial posterior edentulism in the maxilla, not shown in the teaching case in this chapter, is also considered mainstream. In such cases, length is measured from the distal of the nearest tooth root or from the mesial border of the sinus to the distal of the tuberosity. Depth is measured in the posterior mandible from the crest of the ridge to the roof of the inferior alveolar canal, distal to the mental foramen, and in the posterior maxilla, from the crest of the ridge to the inferior border of the sinus.

Outline the “usable” available bone on the radiograph to visualize the length and depth of available bone into which the implants will be inserted, according to the principles described in Chapters 3 and 9. When determining width, be mindful of the differences in gingival thickness between the mandible and maxilla. In the mandible, placing a caliper on the gingiva 1 to 2 mm from the crest and subtracting 2 mm from this measurement accurately gives the width of the ridge (Fig. 11-8). In the maxilla, passing the caliper measuring points through the tissue until they touch bone is the most accurate method.

Rarely, what are thought to be mainstream root form cases in the maxilla must be aborted because of insufficient ridge width following direct observation after tissue reflection. In almost all such cases, plate/blade forms can be substituted if natural co-abutments are available. Some practitioners have plate/blade forms available as backup implants before the insertion procedure begins, in case this situation is encountered. With length and depth quantified, and width within acceptable limits for the chosen modality, it is time to select the ideal implant configuration.

Select the Ideal Implant Configurations for Placement Within the Available Bone

The first consideration is to ensure that the case is not underengineered and that each implant intended to individually support an overlying crown is of sufficient dimensions to function long-term in health. The diffusion-bonded microsphere interface of the Innova Endopore system allows the use of shallower configurations than when using conventional root forms, without underengi-

neering. The posterior of the mouth in the second premolar and molar areas is subjected to approximately four times more functional force than the anterior.⁶ This is because the musculature in the posterior is designed to clench the jaw, whereas the anterior is in the presence of the opening into the oral cavity. Posterior implants have a bigger job to do, and they can do it given adequate available bone. Each patient's strength, habits, and diet bear on the selection of implant configuration. The implant must be large enough to succeed. If too small, the case will be underengineered, and the implant could fail as a result of hyperfunction. On the other hand, if the implant is too large, the case will be overengineered, and failure could result from hypofunction. Ideally, implants 4.1 mm in diameter and 9 mm in length are used in these areas. They offer optimal interface area for the typical patient to ensure that the case will be engineered properly.

In the teaching case, the width of the ridge crest is reconfirmed to be at least 6.1 mm measured at or approximately 1 to 2 mm below the crest in the specific positions where implants are to be inserted. Now, viewing the radiograph that was marked earlier to show the “usable” available bone, depth is measured from the ridge crest down to the roof of the alveolar canal to confirm the existence of a depth of at least 10 mm of available bone. At least 1 to 2 mm of clearance is desired beyond the base of the inserted implant, which is 9 mm in depth. If the radiograph indicates adequate depth, as it does in the teaching case, final confirmation is obtained by placing an overlay of the chosen implant over the radiograph. The overlay is a clear film supplied by the manufacturer, on which are imprinted life-sized representations of every available implant configuration. By passing the imprint of the selected implant, in the teaching case 4.1 mm in diameter and 9 mm in depth, over the periapical radiograph marked to show the extent of usable available bone, the optimal location of each planned osteotomy can be determined (Fig. 11-9). This also shows the amount of clearance between each implant and its closest landmarks. This step is a valuable final confirmation that the implant configuration that has been selected is in fact appropriate. In the teaching case, our pre-operative judgment is that although an implant of 12 mm depth could probably be inserted in one or two of the positions, it is advisable to use implants 9 mm in depth. Because of the efficiency of the interface of the implants used in this case, insertion of implants 12 mm in depth might overengineer the case, putting the implants in a state of hypofunction and possibly resulting in crestal bone loss. This additional support is not indicated in the teaching case, because the patient has no history of excessive bruxing or wear and tear resulting from detrimental personal habits, and because the implants are not anticipated to bear forces of an exceptional nature. One more consideration is essential. Three millimeters of bone is optimal between each implant, and between an implant and an adjacent tooth. Because three implants of 4.1 mm diameter will be inserted, an overall available bone length of 24.3 mm is re-

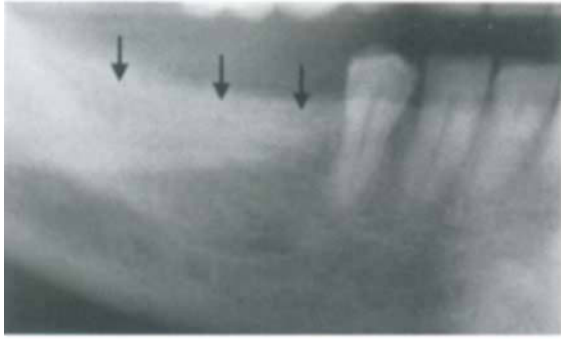


FIG. 11-9 ■ Planned osteotomy locations (*arrows*).

quired. In the teaching case, the total mesio-distal length is sufficient.

Having confirmed that the configuration is appropriate, the implants are ordered. When delivered, the manufacturer's control and lot number for each implant is entered into the patient's record.

Shallower and deeper implants of the same diameter often are ordered as backups, in case osteotomy preparation necessitates ridge height reduction, or reveals either very hard dense bone or excessively soft bone at the insertion visit (Fig. 11-10). The shallower configuration can safely be used in the hard dense bone, whereas the deeper implant may offer a wider margin of safety in soft bone to guard against hyperfunction.

Hexed Cementable Abutment With Retaining Screw Option

Prosthesis retention in the teaching case is achieved using hexed cementable abutments with retaining screws. Using cementable abutments makes prosthodontic restoration as close to conventional restoration as possible. This decision is best made at the time of treatment planning, after selection of the implant configuration in consideration of the available bone, because the method of prosthesis retention dictates the components, transfer copings, and analogs that will be required for treatment. These components are ordered in coordinated dimensions. When delivered, manufacturer control and lot numbers are entered into the patient's record.

Implant Positioning Stent

An implant positioning stent is an effective guide for the placement of each implant. Each implant must be positioned properly for good esthetics, adequate embrasures, and proper occlusion. The crest of the healed edentulous ridge is always lingual to where the central fossae of the teeth were when they were in position. Therefore, the implants should be positioned as close to the buccal of the



FIG. 11-10 ■ Backup implant selection.



FIG. 11-11 ■ Existing denture used as implant positioning stent.

crest as possible. The healed crest is lingually orientated because the main resorption of bone postextraction takes place at the expense of the buccal and labial plates, and also of the ridge height. In addition, the implants should have approximately 3 mm of proximal clearance from adjacent teeth and other implants. Optimal implant positioning is also influenced by conditions in the opposing arch. Preoperative mounted models are sent to the laboratory. There, a removable stent is fabricated, indicating not only the planned location of each implant, but guiding the planned long axis of drilling for each osteotomy. In some cases, an existing partial denture can be adapted and used as a preinsertion positioning stent (Fig. 11-11).

Prescribe Preoperative Medication

Prescribe preoperative medication for the insertion visit as discussed in Chapter 9. Recall that preoperative administration of anti-edema medication is generally not required for mainstream cases, unless the patient's history suggests that edema may be greater than normal. Nor is preoperative sedation recommended. Patients who take prophylactic aspirin daily are advised to discontinue doing so for at least 3 weeks preoperatively, to help ensure normal clotting at the insertion visit.

BOX 11-3 ■ VISIT 1: IMPLANT INSERTION

Confirm use of prophylactic antibiotic
 Set up instrumentation
 Administer anesthetic
 Mark osteotomy locations
 Make incision
 Reflect tissue
 Reconfirm osteotomy locations
 Prepare osteotomies
 Evaluate osteotomy suitability
 Insert implants
 Install cover screws
 Perform soft-tissue treatment
 Suture
 Provide provisional prosthesis if necessary
 Provide home care instruction
 Schedule follow-up visit

VISIT 1: IMPLANT INSERTION
AND PROVISIONAL PROSTHODONTICS

The steps that are performed during the implant insertion visit are shown in Box 11-3.

Confirm That Preoperative Medication
Has Been Taken

As discussed in Chapter 9, it is not necessary to postpone the case if the patient has not taken his or her preoperative prophylactic antibiotic medication. The practitioner should have antibiotics on hand for immediate preoperative administration in such cases. If a patient who had been following an aspirin regimen has not discontinued its use, insertion may nonetheless be performed, with delayed clotting expected.

■ Instrumentation Setup—
The Armamentarium

Two sterile tray setups are recommended. The first, which holds all instruments that are not directly related to implant insertion, is described in Chapter 9.

The second surgical tray holds all instruments involved with implant insertion and protection during submerged or semi-submerged healing, as well as the implants themselves and all implant components. The loaded trays are placed side by side.

The second tray should include a semi-lunar tissue punch, pilot drill, drill extension, paralleling pin, implant bur, **osteotomes**, **trial fit gauge**, mallet, offset punch handle, stainless steel punch tip, hex driver set including housing and tips, the implants and their cover screws, straight and flared healing collars, and straight and flared transfer copings. The standard dedicated implant insertion instrument kit is illustrated in Fig. 11-12.

Sterilization is performed before surgery, as with all dental treatment instrumentation.



FIG. 11-12 ■ Selection of specialized implant insertion instrumentation.

Presurgical Treatment

Prepare the surgical field, administer local anesthetic containing vasoconstrictor to promote comfort and control of bleeding, and prepare the oral cavity and targeted tissues according to the principles and procedures described in Chapter 9.

Score the Ridge to Mark the Selected Position
of Each Osteotomy

Place the adapted partial denture positioning stent intra-orally, and precisely transfer a mark to the gingiva at the location of each planned implant osteotomy (Fig. 11-13). Remove the positioning stent. With a No. 6 round bur in a contra angle with coolant, penetrate the gingiva and score the bone to a depth of approximately 1 mm at each planned osteotomy location (Fig. 11-14).

Following incision and tissue reflection, these score marks guide implant positioning. Score marks are created at this point in the procedure because following tissue reflection, the provisional denture that is used as the positioning stent may not seat accurately. If an existing partial denture is not available, a clear stent is fabricated that seats over adjacent teeth. Using such a stent, the score marks can be created before or after tissue reflection.

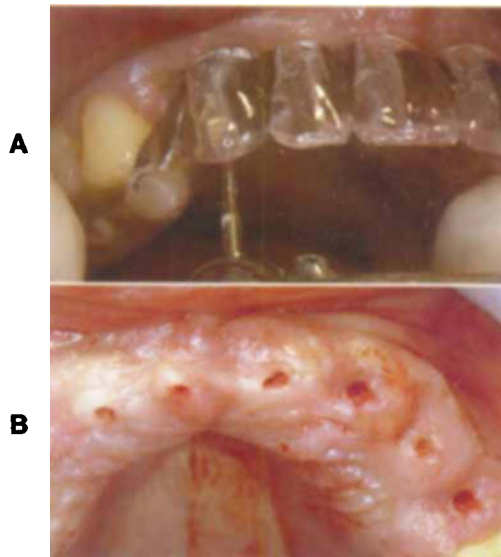


FIG. 11-13 ■ Clear shell implant positioning stent (A) and gingiva marked to show planned osteotomy locations (B).



FIG. 11-14 ■ Bone scored at planned osteotomy locations.

Make Incision

Evaluate the attached gingiva, plan the incision line, incise, and ensure hemostasis according to the principles and procedures described in Chapter 9 (Fig. 11-15).

The extent of the incision should be from the distal of the most distal remaining natural tooth to a point approximately 5 mm beyond the most distal score mark.

Reflect and Prepare Tissue Before Insertion

Reflect the tissue using the periosteal elevator, trim the tissue flap edges to ensure healing by primary intention, and cleanse and alter the exposed alveolar ridge as required according to the procedures and principles described in Chapter 9 (Fig. 11-16).

Reconfirm or Change Location of Implant Osteotomies

Reinspect the ridge crest and observe the location of each of the three planned osteotomies, as indicated by the 1-mm-deep score marks prepared before tissue reflection



FIG. 11-15 ■ Incision of tissue.



FIG. 11-16 ■ Reflection of tissue for ridge exposure.

(Fig. 11-17). Consider the anatomy of the bone at each score mark, and determine whether it would be better if the mark were moved 1 or 2 mm. Usually this amount of deviation will not affect the restorative procedure. If desired, rescore the ridge at a more appropriate point nearby.

One may encounter an imperfection, undercut area, or lack of sufficient width precisely at the location of the score mark. If so, this site is best avoided. If relocation is considered, be sure not to approach too closely to an adjacent implant or tooth, and if possible stay positioned beneath the anticipated final location of the band of attached gingiva.

Prepare Implant Osteotomy

Basic Considerations of Osteotomy Drilling. All osteotomy drilling is performed with copious coolant to control temperature. A high-quality, low-speed, high-torque drilling unit with control of speed, torque, and coolant is



FIG. 11-17 ■ Score marks (highlighted) for planned osteotomy locations.

required. Following the drilling speed protocols is important to ensure that bone will not be damaged during osteotomy preparation. Excess pressure should be avoided. Intermittent drilling is a must. Frequent drill withdrawal followed by lavage and careful suctioning to remove unwanted bone chips from the partially prepared osteotomy is advised. Place the suction tip at the edge of, but not directly over or into the osteotomy.

The osteotomy is formed using only two drills: the pilot drill and the coordinated implant bur. The pilot drill creates a pathway of controlled angle, width, and depth to guide the implant bur in the final formation of the osteotomy.

The point of initial entry is indicated by each score mark placed on the alveolar ridge as previously described. These score marks also act to stabilize the drill position at the time of initial bone penetration.

The pilot drill does not create the final shape of the osteotomy. Nonetheless, it is best to establish as accurately as possible the bucco-lingual and mesio-distal angle at which the drill will be held as it penetrates bone.

Every effort is made to be accurate at every step of the procedure to obviate the need for corrections as one proceeds. Try to visualize in the mind's eye the angle of the long axis of the implant within bone. Consider the relative benefits of bisecting the cortical plates to take best advantage of available bone, and slightly altering this position in favor of coming as close as possible to prosthodontic parallelism. Any alteration in the position of an osteotomy must be slight to avoid bone perforation.

In cases in which a series of implants will be inserted, such as the teaching case, it is best to complete each step for each of the osteotomies before moving on to the next step. Start at the posterior site, and keep the field of operation as clear as possible as successive osteotomies are treated moving anteriorly. The adjacent tooth acts as a paralleling guide in the preparation of the osteotomies. The anterior implant should not be placed too close to the natural tooth. Insert a paralleling pin when each pilot drill pathway is completed.

The paralleling pin protrudes to act as a further guide in correctly angling the pilot drill for the next osteotomy.

To prepare the final osteotomies, the coordinated implant bur is placed in the contra angle. Proper use of the implant bur is a key to success. The implant bur is equal in diameter to the implant, and because it is tapered, the osteotomy it creates allows for frictional fit between the implant and bone to promote early healing in an immobile environment. It is counterproductive to move the contra angle in any way that will enlarge the osteotomy, which can necessitate redrilling to deepen the site to obtain frictional fit.

Before entering the hole created using the pilot drill, again mentally establish the ideal axis of drilling. Keep it in mind at all times, and hold steady as the implant bur is used intermittently until the final depth is reached. One desires a fixed axis of entry, controlled pressure at recommended speeds, copious coolant, intermittent drilling, and frequent lavage.

Pilot Drill Pathway. Review the preoperative assessment of how many millimeters of bone exist beyond the depth of the planned implant to the nearest landmark. Consider the width of the ridge at the planned point of first entry, which is the most posterior planned osteotomy site. If there are a few millimeters of extra available bone depth and widening the ridge is desirable, its height may be reduced using a tapered or round carbide bur at 2000 to 3000 revolutions per minute (rpm). In mainstream cases this may not be necessary.

Although it is common practice, it is best not to have to ramp down the ridge crest so as to preclude as much early resorption as possible. Do so only if the case will clearly benefit.

If the score mark in the ridge crest must be refreshed or deepened, do so now with a No. 6 bur at a speed of 1800 to 2000 rpm. Then place the pilot drill in position, and drill at the axial inclination planned for the osteotomy at no more than 1000 rpm to the desired depth to create a pathway for the implant bur. Cleanse the area (Fig. 11-18).



FIG. 11-18 ■ Use of pilot drill in osteotomy preparation. Note paralleling pins.

The pilot drill is parallel-sided and clearly marked at depth levels of 7, 9, and 12 mm to indicate to the practitioner the current depth at every moment of drilling, so one can stop penetration at the appropriate depth. Drilling is a strictly controlled procedure.

The implants, which are tapered, are supplied in diameters of 3.5, 4.1, and 5.0 mm. The corresponding pilot drill diameters are 2.5, 3.25, and 4.0 mm. The 3.25-mm diameter pilot drill is used in the teaching case to coordinate with the 4.1-mm implant. Many practitioners prefer to start penetration using the 2.5-mm pilot drill in all cases, regardless of the implant diameter, and successively increase the pilot drill diameter until the final corresponding diameter that the case calls for is used.

In cases in which an adjacent tooth may interfere with the ability of the contra angle to carry the drill to its desired depth, a drill extension is used. The extension lengthens the attachment arm of the pilot drill and implant bur to enable their use in such cases.

In properly diagnosed cases with an appropriately selected implant configuration, encroaching on landmarks should not be a concern.

Completion of the Implant Osteotomy. Each implant configuration has a corresponding implant bur. The 4.1-mm diameter, 9-mm depth implant bur coordinates with the implants in the teaching case. It is carefully placed and angled at the opening of the pathway created using the pilot drill, and is brought to its desired depth at a speed of 800 to 1000 rpm with constant coolant supply (Fig. 11-19). After penetration to the final depth, cleanse the area. The osteotomy is ready for a trial fit gauge to verify correctness before implant seating.

Note that the speed of drilling when using the implant bur is as controlled as when using the pilot drill. Every effort is made to control heat production. Intermittent drilling, low pressure, and repeated cleansing are always recommended.



FIG. 11-19 ■ Use of implant bur in osteotomy preparation.

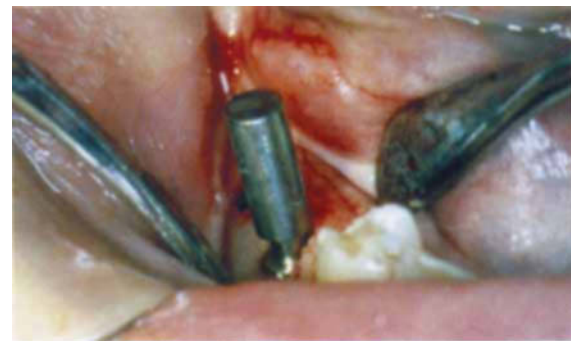


FIG. 11-20 ■ Use of trial fit gauge to check osteotomy preparation.

Evaluate and Test Prepared Osteotomy

A smooth-sided, tapered replica of the selected implant configuration is used to check the prepared osteotomy. This trial fit gauge has a coronal projection for ease of handling. With gentle pressure, the gauge is partially inserted into the osteotomy (Fig. 11-20) and then malleted into position. This also serves to compact the bone of the osteotomy walls. One must observe that all points of the coronal edge are at or below the crest of bone. If this is the case, then the site is sufficiently deep. There are two ways in which this trial fitting may indicate that the site is not acceptable. If the trial fit gauge does not seat all the way, such that its coronal edge is not below the crest of bone, then the osteotomy is too shallow. In this case, the implant bur should be reinserted to deepen the osteotomy sufficiently to allow the trial fit gauge to seat properly. On the other hand, if the coronal edge is at or below the crest of bone but the trial fit gauge is loose, then the osteotomy has been prepared wider than the diameter of the implant. The way to remedy this is the same as if the osteotomy is too shallow. Because the implant and osteotomy are tapered, the osteotomy can be deepened to ensure a snug fit. In such cases, radiographically confirm that clearance is adequate beyond the depth of the osteotomy to the nearest landmark. The trial fit gauge is removed by turning it in only one direction so as not to widen the osteotomy.



FIG. 11-21 ■ Implants before final seating.



FIG. 11-23 ■ Healing collars placed for semi-submerged healing at implant insertion visit.



FIG. 11-22 ■ Final seating of implant.



FIG. 11-24 ■ Tissues sutured over cover screws for submerged healing at implant insertion visit.

Note again that this procedure is carefully controlled. Every step is carefully performed and checked to ensure that the steps that follow can be performed successfully. In this way, one can always know exactly why a problem occurred and what step in the procedure it is related to, so it can be corrected immediately.

If the coronal edge of the implant is not entirely below the ridge crest, tap again with the mallet. Once it is firmly in position, do not remove it. If the implant is not snugly in place, whether or not it is below the crest of the ridge, remove it, confirm adequate available bone beyond the depth of the osteotomy, refurbish and deepen the osteotomy with the implant bur, and reseal the implant. Cleanse the area.

Final Seating of the Implant

Aseptically transfer the implant to place it into the prepared osteotomy. When the implant is removed from its sterile packaging, deliver it directly to the osteotomy. Do not bring the implant into contact with gauze or any surface other than its original packaging. Immediately following placement into the prepared osteotomy, disengage the delivery tool supplied with the implant using a gentle rocking motion (Fig. 11-21). Engage the metal punch tip into its offset punch handle, and position it onto the implant screw cover such that the long axis of the handle is parallel to the long axis of the implant (Fig. 11-22). Select from the coordinated hex driver set a driver of sufficient length for ease of finger manipulation during use. Using a mallet, deliver several sharp taps to the end of the offset handle, until the implant is seated at or below the crest of bone. Cleanse the area. Implant insertion is complete.

Secure Healing Collars for Semi-Submerged Healing, or Cover Screws for Submerged Healing

If the semi-submerged healing protocol is desired, healing collars are placed. Healing collars are supplied straight and flared. If the teaching case followed the semi-submerged healing protocol, the straight healing collars would most likely be used for the premolar implant, and flared healing collars for the two molar implants. Healing collars are supplied in various lengths to match the thickness of the gingival flap. The healing collar can be flush with the gingival flap, or up to 1 mm above it after suturing. The selected healing collars are seated firmly in the same manner as cover screws (Fig. 11-23).

If submerged healing is desired, as in the teaching case, cover screws are replaced and fastened with the appropriate driver selected from the hex driver set (Fig. 11-24). The

selected driver is of sufficient length to ensure adequate finger manipulation to obtain a secure fit.

Note the versatility of this system. Healing collars obviate the need for implant exposure after 4 to 6 months of healing, but they must not be in function during the healing period. Provisional removable dentures seated over healing collars must be completely relieved to ensure that no functional forces are passed to the implant during healing.

Postinsertion Soft-Tissue Procedures

If required because of the presence of flabby tissue at the incision site or excessively thick maxillary gingiva, remove any excess tissue that will interfere with coapting the flaps. Decrease flap thickness and reduce flabby tissue if required according to the procedures and principles described in Chapter 9.

Whether or not these plastic surgery procedures are required, in the case of semi-submerged implants with healing collars, tissue punch to ensure an ideal pergingival site by removing tissue that bunches around the collar upon coapting, again according to the procedures described in Chapter 9. When the soft tissue is completely ready for suturing, take a periapical radiograph for the patient record.

Final Closure—Suturing

Suture according to the principles and procedures described in Chapter 9. When the semi-submerged protocol has been followed, the attached gingiva is positioned and sutured in place around each healing collar. When healed, the attached gingiva will predictably be at the pergingival site, exactly where it was placed.

Often, the reflected flaps are sutured completely over the implant for total submersion. This technique has the advantage of full protection during healing and the disadvantages of not ensuring the presence of attached gingiva at the pergingival site and requiring a second surgical intervention to expose the implant following healing. Every effort is made to ensure that the cuff around the implant will be in attached gingiva at the time of exposure. However, it may not always be possible to place the implant directly under attached gingiva and at the same time optimally position the implant a bit toward the buccal of the crest to enhance the occlusal relationship. In such a case, follow the semi-submerged healing protocol if possible, because the loosely reflected tissue flaps are sutured into position with attached gingiva around the healing collars.

Provisional Removable Prostheses

When possible, it is desirable that removable provisional prostheses not be used. If the area of treatment is in a reasonably nonesthetic area, as many posterior cases are, and the patient's temperament can accommodate not having

replacements during healing, avoiding provisional restoration diminishes the opportunity for complications related to unwanted occlusal forces acting on implants during healing. When a provisional prosthesis is required because the implants have been inserted in an esthetic area, or because of patient insistence even when the implants are in a nonesthetic area, it must be fitted carefully. If a previously used removable partial denture is used as the provisional restoration, reduce its entire tissue surface over the area of treatment, relin with a soft-tissue treatment type of reliner, and trim and adjust the borders. Check the occlusion and adjust it to be light, particularly if the patient tends to clench or grind. Next, relieve the tissue surface areas immediately over each of the three healing collars of semi-submerged implants, or the gingiva over the inserted submerged implants, such that when seated there is at least 1 mm of clearance.

No force should be applied to a healing root form implant following the protocol to achieve osteointegration. Dietary constraints also help to promote afunctional healing.

Postinsertion Home Care Instruction

As discussed in Chapter 9, advise the patient about possible effects resulting from the trauma of the surgery, and prescribe comfort medication and prophylactic medication. The patient is also instructed in proper postoperative cleanliness and maintenance of a soft diet to ensure that excessive function of the implant will not interfere with tissue integration.

Postinsertion General Considerations

In cases of normal healing, to follow the required case sequencing, the next appointment is made an average of 4 months after suture removal in the mandible, and 6 months after suture removal in the maxilla.

These healing periods allow for direct bone ingrowth and apposition into the microsphere interface, which is the point of osteointegration. Of course, by the time of the next appointment, the overlying soft tissues will have healed completely.

Following 4 to 6 months of healing, the patient is scheduled for implant exposure.

Visit 2: Postinsertion Follow-Up Visit

As described in Chapter 9, a postinsertion follow-up visit is scheduled for 7 to 10 days after implant insertion (Box 11-4). At this time, conduct a general evaluation, remove the sutures, evaluate soft-tissue healing, and check and adjust the fit of the provisional removable prosthesis, if used.

BOX 11-4 ■ VISIT 2, WEEK 1: SUTURE REMOVAL AND INTERIM EVALUATION

Perform general evaluation
 Remove sutures
 Evaluate soft-tissue healing
 Check and adjust removable prosthesis, if required

BOX 11-5 ■ VISIT 3, WEEK 16: IMPLANT EXPOSURE, DIRECT BONE IMPRESSIONING, AND INTERARCH OCCLUSAL REGISTRATION

Confirm use of prophylactic antibiotic
 Set up instrumentation
 Administer anesthetic
 Identify implant locations
 Expose implants
 Remove cover screws
 Place transfer copings
 Perform direct bone impressioning
 Install healing collars
 Perform interarch occlusal registration
 Conture and suture tissue
 Select shade
 Provide home care instruction
 Schedule follow-up visit

VISIT 3: IMPLANT EXPOSURE AND DIRECT IMPRESSION

The steps that are performed during the implant exposure and direct impression visit are shown in Box 11-5.

Preoperative Medication

When the submerged healing protocol is followed, the gingival tissue overlying each implant must be removed. This is a minor procedure. Most practitioners do not premedicate the patient, unless it is advisable for peripheral medical reasons.

If premedication is indicated, follow the same guidelines as for premedication before implant insertion. Edema is almost never observed after implant exposure.

**■ Instrumentation Setup—
The Armamentarium**

The tray setup for these procedures is far simpler than that for implant insertion. Only one tray is required. A coordinated cover screw trephine (4.1 mm in the teaching case), hex driver set, small scalpel, Noyes scissors, tissue holder forceps, mallet, orangewood stick, final and provisional

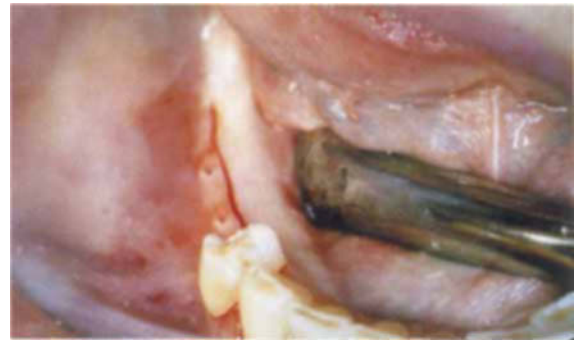


FIG. 11-25 ■ Implant locations marked before exposure.

cementation setups, hemostatic agent, mirror, and explorer are the essentials.

Any other instruments of personal preference that facilitate treatment should also be included.

Preoperative Tissue Preparation

The same regimen performed before implant insertion is repeated, including thorough inspection of the oral cavity to locate and remove any residual food particles, thorough lavage, and application of a topical bactericidal agent.

Local Anesthetic, Promotion of Comfort, and Control of Bleeding

Except in the rare cases in which the patient's history or medical condition indicates that special precautions should be taken, use of a local anesthetic containing vasoconstrictor is sufficient. Only infiltration is required. Following administration of a topical anesthetic, the buccal fold is infiltrated along the edentulous area, and the entire ridge crest is infiltrated.

Try to deposit the anesthetic along the crest and directly over each implant. Placing the implant positioning stent used at the time of insertion may help at this time.

Recording of Implant Locations

If the submerged healing protocol has been followed, place the implant positioning stent and mark the probable position of each implant using an indelible tissue marker (Fig. 11-25). Remove the stent and carefully palpate the area to identify the perimeter of each implant. Mark each location if it is different from the mark made using the implant positioning stent.

In case the outline cannot be "felt" accurately, it may be necessary to probe through the tissue using a sharp explorer, at least for initial orientation.

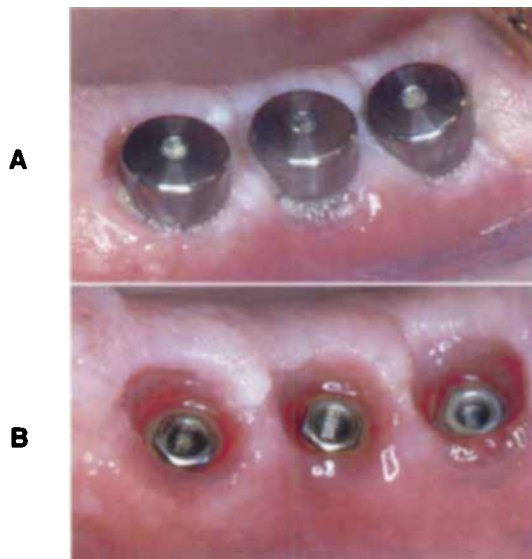


FIG. 11-26 ■ Healing collars in position (A) and removed (B).

Implant Exposure

If the semi-submerged healing protocol was followed, an appropriate hex driver is seated on the distal implant's healing collar. Using as little torque as possible, carefully turn the hex driver to remove the healing collar. Remove the three collars in this manner.

Little or no bleeding should be observed at this time. One may observe healed gingival cuffs following the contours of the straight or flared healing collars, if the semi-submerged treatment protocol was followed.

In cases that follow the submerged healing protocol, after administration of local anesthetic, incise the tissue along the same incision line created at the time of implant insertion, and reflect the flaps to expose the implants and their cover screws. This option is generally preferred over the use of a trephine to expose the implant.

Inspect and cleanse the area around the implant periphery. Control bleeding with direct pressure. If necessary, further infiltrate with local anesthetic containing vasoconstrictor.

Select an appropriate hex driver from the hex driver set, nest it to the cover screw of the most distal implant, and remove it as gently as possible. Cleanse the area. Keep bleeding under control. Repeat the process for each cover screw, proceeding from the most distal to the most mesial (Fig. 11-26).

Again, carefully inspect the area. Remove tissue tags, if present, with a Noyes scissors or other suitable instrument. Cleanse the area again.



FIG. 11-27 ■ Transfer copings in position.



FIG. 11-28 ■ Master impression over transfer coping.

Direct Impression for Hexed Abutment Selection/Fabrication

Placement of Transfer Copings. Coordinated transfer copings are supplied for each implant diameter. In the teaching case, 4.1-mm diameter transfer copings are used. An appropriate straight or flared transfer coping is selected for each implant.

If the 4.1-mm diameter of the implant is esthetically compatible with the anatomy of the planned restoration of a tooth—for example, in the premolar location—a straight transfer coping may be best. In the case of molars, if having a wider diameter at the pergingival site of the final crown would enhance restorative esthetics, a flared transfer coping is advised. If the semi-submerged healing protocol has been followed, select a straight transfer coping where there is a straight healing collar, and a flared transfer coping where there is a flared healing collar.

Attach the selected transfer copings to the three inserted implants (Fig. 11-27). Cleanse the area.

Direct Bone Impressioning. To supply the laboratory with the information it needs to pour an accurate model, a direct bone impression is now taken with the transfer copings in position. This impression may be taken with any accepted elastic impression material, preferably the type currently used in one's conventional crown and bridge procedures. The impression is taken with an open tray to allow the transfer coping to project through the impression material (Fig. 11-28). If excess impression material covers the



FIG. 11-29 ■ Impression removed with transfer copings.

end of a transfer coping, trim it to expose the screw that secures it into position. A closed tray may be used in cases in which the implants are sufficiently parallel to each other to permit the impression to be removed easily.

Taking the impression with an open tray allows direct access to the screws that hold the transfer copings positioned against each implant.

Remove the three transfer coping attachment screws, and then remove the impression from the oral cavity (Fig. 11-29). Because the transfer coping retaining screws have been removed, regardless of the degree of parallelism or lack thereof, the impression can be removed easily.

To maintain sterility, dedicate an impression material setup exclusively to this procedure. After the impression has been taken and removed, be sure to cleanse the area completely. No residual impression material may remain against bone or any portion of the implant.

Cleanse the transfer coping attachment screws. Place them through the transfer copings held securely within the impression material, and screw each one down against a correctly positioned coordinated implant analog (Fig. 11-30).

The impression with this assembly is delivered to the laboratory, with the transfer copings attached to three 4.1-mm implant analogs. The laboratory pours an accurate model for the selection of straight, flared, or angled cementable abutments, or fabrication of custom-made cementable abutments. The laboratory also is responsible for the fabrication of the three individual provisional acrylic restorations, and three metal castings with bisque bakes for the final crowns.

Place or Replace Healing Collars. When the direct impression has been taken, and the transfer copings have been removed with the impression, place or replace the healing collars to prepare to take interocclusal/opposite arch registrations. The direct impression, with the transfer copings in place, is set aside to be sent to the laboratory with the interocclusal/opposite arch registrations.



FIG. 11-30 ■ Implant analogs attached to transfer copings.

Interocclusal/Opposite Arch Registrations

The original study model of the opposite arch is included in the delivery to the laboratory. If one wishes to retain this model, it can be duplicated, or one can reimpression the patient and pour another model of the opposing arch.

After taking the direct bone impression, removing transfer copings, and placing the healing collars, an interarch occlusal registration is recorded before closure. After removing the transfer copings from the implant analogs on the laboratory model, this bite is used to relate the opposing models for articulation. The articulated models are then used for selection and/or fabrication of the hexed cementable abutments, the provisional restorations, and the metal castings with bisque bakes for the final crowns.

It is preferred that bite registrations and counter models be obtained according to whatever procedure is commonly used in one's conventional office routines. When these procedures are complete, the area is again cleansed thoroughly.

Contour Tissue and Suture

When the tissue is coapted around the healing collars, contour tissue to alleviate bunching. Close with interrupted sutures.

Select Shade

As discussed in Chapter 9, the practitioner now selects the shade to be used in the restoration. In the teaching case, the shade is used both for a provisional removable prosthesis and for the final fixed bridgework.

BOX 11-6 ■ VISIT 4, WEEK 17: SUTURE REMOVAL AND INTERIM EVALUATION

Perform general evaluation
 Remove sutures, if required
 Evaluate soft-tissue healing
 Check and adjust removable prosthesis, if required

Immediate Postexposure Home Care Instructions

Trauma. The implant exposure procedure is almost never traumatic. Postoperative edema is seldom observed. Starting on the second day, rinsing with a mild salt water solution or with chlorhexidine is advised.

Prophylactic Antibiotic Medication. Unless indicated for medical reasons, prophylactic antibiotic medication is not necessary.

Comfort Medication. Most often, comfort medication is not required. A prescription for ibuprofen (Motrin) 400 mg, 6 tablets, to be taken one every 4 to 6 hours only if necessary may be given to promote patient ease and confidence.

Cleanliness. During early healing of the soft tissues after implant exposure, flossing is not recommended, because it can disrupt delicate healing. Gentle lavage or rinsing is advised starting on the second day.

Diet/Function. The patient is advised not to eat on the side with the provisional teeth. A soft diet is recommended.

Visit 4: Postexposure Follow-Up Visit. The patient is scheduled for a follow-up visit 10 to 14 days after the implant exposure visit (Box 11-6). Healing and the provisional restorations are checked. In the case of submerged healing, the sutures are removed at this time.

If healing is complete, the restorative procedure may start immediately. If healing is incomplete, the restorative procedure is delayed for another 1 to 2 weeks.

RESTORATIVE PROCEDURES**General Considerations**

Three parallel abutments protruding into the oral cavity are placed and treated as though they were prepared teeth to perform the restorative procedures.

The same process conventionally used in one's office for the fabrication of three individual adjacent crowns is followed.

Generally Accepted Restorative Criteria

Articulated models are made from master impressions and interarch occlusal registrations. Most often the final crowns are fabricated of porcelain fused to metal, but they can also



FIG. 11-31 ■ Example of laboratory master model.

be of gold with porcelain facings, or in marginal cases in which one desires to reduce the occlusal force transmitted through the implants, they can be fabricated of baked acrylic over gold copings. The provisional crowns are fabricated of acrylic.

All of one's knowledge related to the fabrication of provisional teeth on natural abutments is applied now. Tooth contours, marginal fit, embrasures, and basic shade selection, all of which can now be modified, are considered carefully to create the final restorations. The same criteria are used for the final crowns.

Hexed Cementable Abutments and Provisional Crowns

With the master direct bone impression with transfer copings in place, implant analogs, counter models, and interocclusal bite registrations are all carefully labeled, wrapped, and sent to the laboratory with a prescription. The prescription instructs that appropriate hexed cementable abutments be purchased or fabricated as indicated, and that three individual provisional crowns and bisque-baked final crowns be fabricated. The provisional crowns are occluded and contoured as though they were provisional crowns on natural abutments, taking into account modifications necessitated by root form implant prosthodontics.

Master Model. At the laboratory, the technician confirms secure attachment of each transfer coping to an implant analog in the master impression. With all three transfer copings and implant analogs securely in position, the master model is poured, separated from the impression, and trimmed. The transfer copings are removed (Fig. 11-31).

FIG. 11-32 ■ Example of articulated master model.



FIG. 11-33 ■ Cementable straight abutments (arrows).



FIG. 11-34 ■ Cementable flared abutment (arrows).



The master model is now a duplicate of the mandible, with each implant analog seated exactly where each implant was placed in the surrounding bone. Because the bite registration was taken without the transfer copings in place, the model is now ready for seating into the bite with no interference.

Articulated Models. The master model is mounted to the articulator favored by the practitioner, the bite registration is carefully fitted over it, and the counter model is seated into the opposing side of the bite registration. The articulator is closed, the vertical stop set, and the opposing model fastened into position. When the fastening medium is set, the articulator is opened and the bite removed (Fig. 11-32).

The articulated models are ready to use. The relationships among the inserted implants, the adjacent teeth, and the opposing arch are clearly shown.

Hexed Cementable Prefabricated Abutment. If the long axis of an implant is within 5 degrees of parallel to the long axis of the path of insertion of the planned crown or splinted prosthesis, a manufacturer-supplied hexed straight (Fig. 11-33) or flared (Fig. 11-34) cementable abutment is used. As with all implant components, the abutment diameters are coordinated with the implants. In the teaching case, hexed cementable abutments of 4.1-mm diameter are used. The premolar implant takes a straight abutment, supplied in 7-mm length with a 1.5-mm collar and 9-mm length with a 3.5-mm collar. The appropriate length for

proper interocclusal clearance is chosen. The molars generally take flared abutments, supplied in 10-mm length with a 2-mm collar. These choices are made in consideration of factors already described for choosing healing collars when the semi-submerged healing protocol is followed.

The laboratory fastens these abutments to the implant analogs, using the retaining screw supplied with each one. If necessary, further adjustments for interocclusal clearance are made by shortening the abutments. Clearance of 2 to 3 mm is sufficient.

If the long axis of an implant deviates approximately 15 degrees from the long axis of the path of insertion of the planned crown or splinted prosthesis, a manufacturer-supplied 15-degree angled abutment is purchased in the correct diameter. The angled abutment is fastened to the implant by rotating on the hex until parallelism is observed, and then fastened to the implant analog with the supplied retaining screw.

The manufacturer supplies abutments of 0, 15, and 25 degrees. When fastened, the angle may be adjusted a bit at the laboratory if required to achieve parallelism. Another option is for the laboratory to custom-fabricate abutments, as described below.

Hexed Cementable Custom-Fabricated Abutment.

If the long axis of a prefabricated abutment deviates approximately 7 or 20 degrees from the long axis of the path of insertion of the planned crown or splinted prosthesis, it can be prepared intraorally for parallelism, or a hexed cementable custom abutment can be fabricated at the desired angle and fastened into position using a retaining screw obtained from the manufacturer.

Custom fabrication of abutments prevents restorative difficulties associated with unusual angle requirements, permitting parallelism and proper interocclusal clearance to be routinely achieved. Note that almost always, the available straight and angled hexed cementable abutments can be further prepared at the laboratory to achieve parallelism. The possibility of custom-fabricating an abutment is a comforting option in a case for which the prefabricated abutment angles are not appropriate. When this need arises, the laboratory can fabricate custom-made abutments to satisfy the needs of the case.

Fabrication of Provisional Crowns. With the hexed cementable abutments fastened to the implant analogs on the master model, the laboratory can now fabricate the provisional crowns. Most often, the provisional crowns are fabricated in acrylic. Each individual tooth is formed into the occlusion of choice. The shade previously selected is used. The crowns are polished well and returned to the practitioner on the model (Fig. 11-35) together with their underlying cementable abutments and retaining screws.



FIG. 11-35 ■ Provisional crowns.



FIG. 11-36 ■ Bisque-baked final crowns.

The individual provisional crowns also act to guide the healing of the gingiva following implant exposure if the submerged healing protocol is followed. These crowns usually are flared in the molar area for esthetics and cleansability.

Porcelain-Fused-to-Metal Crowns, Castings, and Bisque Bakes. The laboratory also fabricates and returns three bisque-baked individual porcelain-fused-to-metal crowns (Fig. 11-36). These are made on the model with the final hexed cementable abutments in position on their implant analogs. The margin is carried to the level of union of the implant with each hexed cementable abutment, or sometimes in the posterior, about 1 mm occlusal to it.

Having the bisque-baked castings available at this time allows a trial seating on the implant abutments after they have been cemented.

Considerations Unique to Restorative Implant Dentistry

In mainstream cases, most often the implant abutment protrudes into the oral cavity somewhat lingual to the position of the central fossae of the natural teeth when they were in position.

BOX 11-7 ■ VISIT 5, WEEK 18: ABUTMENT CEMENTATION, PLACEMENT OF PROVISIONAL CROWNS, AND BISQUE-BAKE TRY-IN

Try in cementable abutments
Affix cementable abutments
Trial seat provisional crowns
Try in bisque-baked crowns
Place provisional crowns

The relatively lingual position of the abutments occurs because following tooth loss, the edentulous ridge heals at the expense of ridge height and the buccal plate of bone. Thus, the crest of the healed ridge receiving the implants is lingual to where it was in function.

Therefore, the final crown is fabricated with a thin lingual and greater buccal contour to bring the restoration as close to normal occlusion as possible. This also prevents a cross-bite and an excessively large buccal vestibule that would interfere with the normal positioning of food onto the occlusal table during mastication.

The flared, hexed, cementable abutment helps bring the restoration closer to a normal occlusal relationship with the opposing arch, thereby helping to prevent these problems.

Inspect the buccal-gingival margin around the implant. If it is in attached gingiva, which is desired, ridge lapping of the buccal can be incorporated in the restoration.⁷

Ridge lapping alone solves most esthetic problems, allowing a truly esthetic result to be achieved consistently. Recall that this is an advantage of the semi-submerged healing option, because during closure of tissue around the healing collars, the band of attached gingiva on the buccal and lingual is sutured exactly where it is desired, all around the implant abutment.

A prescription is written instructing the laboratory in the fabrication of the three final crowns. The patient is scheduled for a try-in appointment.

VISIT 5: AFFIX ABUTMENTS, INSERT AND ADJUST PROVISIONAL CROWNS, AND TRY IN BISQUE-BAKED CROWNS

The steps that are performed during the abutment fixation, bisque-bake try-in, and provisional crown insertion and adjustment visit are shown in Box 11-7.



FIG. 11-37 ■ Setting retaining screw into cementable abutment.

Trial Seating of Hexed Cementable Abutments

Prefabricated, straight, flared, and angled hexed cementable abutments have parallel flat surfaces to increase cement retention and resist crown rotation. The laboratory generally positions these flat surfaces on the proximals to increase space for the creation of embrasures. When seating in the mouth, be sure to orient all prefabricated and custom-fabricated hexed cementable abutments on the hex exactly as they were on the laboratory model. Set the retaining screws (Fig. 11-37).

Before doing anything else, radiographically and visually check the margins to be sure that the hexed cementable abutments are fully seated. This is critical and prevents complications. Also check margins for accuracy. Confirm that 2 to 3 mm of interocclusal clearance is present. Consider the parallelism, and observe how the laboratory achieved it.

Hexed Abutment Cementation

Remove the retaining screw and cement the distal abutment first. There are two options. One is to seat with provisional cement, and the other is to seat with final cement. When each implant individually supports a separate crown, as in the teaching case, permanent affixation of the hexed cementable abutment with provisional cement often is the method of choice.

The advantage of using provisional cement is that it allows removal of the abutment should complications occur. Of course, provisional restorations always are provisionally cemented.

Final or hard cementation is the method of choice if the osteointegrated implants will be splinted. Osteointegrated implants are completely rigid. They do not have the resiliency of teeth. When a master impression is taken to obtain the model that will be used to make the final crowns, the hexed cementable abutments should be in their permanent positions.

If a master impression is taken and then the hexed cementable abutments are removed for any reason, the abutments often cannot precisely be replaced in their original positions. This is the major cause of inability to fully seat an assembled superstructure over splinted osteointegrated implants. Therefore, it is important to fix the hexed cementable abutments in place with provisional or final cement and not remove them again. Additional models made from subsequent master impressions, if required for splinted cases, will be accurate.

Identify a mark or make one on the buccal of the hexed cementable abutment for orientation during cementation. Using an appropriate hex driver, remove, clean, dry, and set aside its retaining screw. Remove the hexed cementable abutment from the implant. Handle the retaining screw, and identify the marked buccal aspect. Replace the abutment into the implant to rehearse and perfect its placement. Cleanse, dry, and set aside the abutment next to the retaining screw.

This rehearsal prevents complications. One should be able to properly and efficiently set the hexed cementable abutment correctly into place with its retaining screw when the cement has been mixed.

In the teaching case, permanent affixation is performed using provisional cement. Use one's provisional cement of choice for the placement of conventional crowns and bridges. Thoroughly cleanse and dry the implant. Mix the provisional cement. Allow sufficient working time. Place cement on the surfaces of the hexed cementable abutment that will contact the implant, and seat the abutment with the proper orientation using the buccal marking as a guide. Cover the retaining screw with provisional cement, and set it into final position with an appropriate hex driver.

After the cement has set, carefully remove any excess with an explorer. Be sure to cleanse the pergingival site immaculately all the way down to the junction between the hexed cementable abutment and the implant. Cleanse again.

Trial Seating of Provisional Crowns

Each provisional crown is seated separately, one at a time, starting at the distal and proceeding to the mesial. Each provisional crown is checked for marginal perfection, embrasure adequacy, and proper occlusion, tooth contour, esthetics, and shade (Fig. 11-38).

All necessary adjustments are made on each crown seated alone. Then, all are seated simultaneously to check contact points and recheck embrasure adequacy. Repolish as required.

The provisional crowns are removed, cleansed, dried, and set aside.



FIG. 11-38 ■ Try-in of provisional crowns.



FIG. 11-39 ■ Try-in of bisque-baked crowns.

Try In Bisque-Baked Crowns

When the final individual crowns are returned by the laboratory, they are inspected on the articulated models. They are in the bisque-bake stage. The three provisional crowns are removed. One at a time, the final crowns are tried in. Margins, embrasures, occlusion, tooth contours, and shade are checked for each. Then all are seated at once to check contacts and reconfirm embrasure contours (Fig. 11-39). Particular attention is paid to the relationship between the crowns and their gingival cuffs. Careful recontouring and any other required adjustments are made now.

If the crowns were ridge lapped, check the passive fit at the gingiva and the esthetics of the ridge lap contours that simulate growth through the gingiva, and contour if required.

Remove the bisque-baked final crowns. Seat the provisional crowns with provisional cement. Check everything once again. Cleanse, and make an appointment for cementation of the completed final crowns.

Placement of Provisional Crowns

Trial seat each provisional crown individually, and then all together. Check the embrasures, margins, contours, occlusion, and shade. Remove, cleanse, dry, and set aside each provisional crown.

If the semi-submerged healing protocol is followed for the case, each provisional crown can be temporarily affixed with provisional cement, and this treatment visit is finished. If the submerged healing protocol is followed, as in the teaching case, tissue contouring, tissue punching, and suturing are performed after provisional cementation.

If the semi-submerged healing protocol is followed, the gingival cuffs are healed and correctly contoured. The final individual bisque-baked crowns have already been tried in and adjusted. They are glazed at the laboratory and returned for cementation.

If the option of splinting the three individual crowns is chosen, the laboratory returns three individual porcelain-to-metal castings with no bisque bakes. The three cementable abutments are cemented into position. The three individual porcelain-to-metal castings are placed and adjusted. Interarch occlusal registrations are taken, and a master impression is made. The laboratory pours a model and articulates the case. The three individual porcelain-to-metal castings are splinted. The splint is bisque baked and returned to the practitioner for a try-in to check whether marginal, embrasure, contour, or occlusal adjustments are required. Following any required adjustments the case is glazed, and cemented at a subsequent visit.

In the teaching case, which uses the submerged healing protocol with individual crowns, the provisional crowns act as healing collars, and the contours of the healing gingiva are guided by the crown contours of the provisional teeth.

The hexed cementable abutments are dried, and each provisional crown is provisionally cemented into position. Excess cement is removed, and again the area is carefully inspected to avoid the retention of cement. The occlusion, contours, embrasures, and shade are checked again. Next, the tissue flap is positioned against the provisional crowns and contoured with a tissue punch or scalpel. The case is sutured as previously described. These sutures are removed 7 to 10 days later, at a subsequent visit.

VISIT 6: CEMENTATION OF COMPLETED CROWNS

The steps that are performed during the cementation of completed crowns visit are shown in Box 11-8.

Remove the provisional crowns, and cleanse. Try in the final crowns. Check that the laboratory has properly followed all instructions.

In the teaching case, the final crowns are permanently affixed with provisional cement. The reasons for this are explained to the patient. The fact that the implant is retrievable is discussed. The need to monitor potential crown loosening is emphasized.

The final crowns are cleansed and tried in. The hexed cementable abutments are cleansed and dried. The final crowns are permanently affixed with provisional cement (Fig. 11-40). A mallet and orangewood stick are used to



FIG. 11-40 ■ Seating of final crowns.



FIG. 11-41 ■ Radiograph of completed case.

BOX 11-8 ■ VISIT 6, WEEK 19: CEMENTATION OF COMPLETED CROWNS

- Remove provisional crowns
- Try in final crowns
- Check occlusion, margins, embrasures, and shade
- Cement completed crown

sharply tap each crown into position before the cement hardens.

The crowns are cleansed. All excess cement is removed from under the gingiva, and from anywhere else it may be observed. Periapical and/or panoramic postoperative radiographs are obtained for the record. Periapical radiographs are preferred, and a panoramic can also be useful (Fig. 11-41).

The case is complete.

AFTERCARE AND MAINTENANCE Regimen for Increasing Function

In the case of osteointegrated implants, healing is already advanced by the time the final restorations are placed. The soft and hard tissues around the implant and its components can withstand a regimen of increasing function over a 2- to 4-week period, until full function is reached.

Patients are advised to monitor their function, and if any discomfort is experienced during mastication, to note faithfully and without fail the area of concern and cease chewing there until the problem can be evaluated. Such occurrences are rare. Most often, the period of increasing to full function is asymptomatic.

As discussed in Chapter 9, professional and home maintenance must be performed regularly and diligently to avoid complications.

COMPLICATING AND ATYPICAL CONDITIONS

Common Complicating and Atypical Conditions

The complicating and atypical conditions that are common to the treatment procedures of all of the abutment-providing implant modalities, as discussed in Chapter 9, are applicable here. These include questionable adequacy of ridge width, minimal width of attached gingiva, frayed or torn flaps, excessive bleeding, retained root tip, presence of a cyst or granulomatous tissue, unusual variation in ridge height and/or contours, labial or lingual osseous perforation during osteotomy preparation, fracture of the labial or lingual osteotomy wall, friable tissue at suturing, excessive postoperative edema, and retained impression material. Each of these conditions is rare. Treating these complications properly is discussed in Chapter 9.

Extreme Angle Between Long Axis of Osteotomy and Parallelism Requirements for Hexed Cementable Abutment

The existence of an extreme angle between the long axis of the osteotomy and that required for parallelism of a hexed cementable abutment is rare, because the Innova Endopore implants discussed in this chapter require less depth of insertion into bone to function long-term within physiologic limits of health. This means that the long axis of the osteotomy usually can be at a favorable angle. If not, in cases with very narrow alveolar ridges, use of a custom-made hexed cementable abutment permits parallelism. However, too much discrepancy between the angle of the restoration and that of the inserted implant can lead to a biomechanically compromised situation. In such cases, it is almost always better to splint the implant to another, rather than allow each freestanding implant to individually support a crown.

Minimal Interocclusal Clearance

Ideally, inadequate interocclusal clearance is detected and corrected at the time that the study models are made. If not, this complication is solved in a trade-off of options. If the hexed cementable abutment would still be long enough to provide adequate cement retention following shortening for improved interocclusal clearance, shortening is an acceptable option. If not, then reduction of the

opposing teeth to provide clearance is the best choice. If a series of implants have hexed cementable abutments that are too short to provide adequate cement retention, splinting usually helps, as does the use of final hard cement rather than provisional cement. If none of these options is helpful, a screw-retained rather than cemented prosthesis may be required.⁸

Inadequate Frictional Fit of Implant on Final Placement

Fortunately, inadequate frictional fit is not a problem, because the Innova Endopore implants used in the teaching case are tapered. If encountered, simply deepen the osteotomy by 1/2 mm using the implant bur, and reseal the implant. Be sure to remain sufficiently clear of landmarks.

VARIATIONS AND ALTERNATIVES

Submerged and Semi-Submerged Healing Options

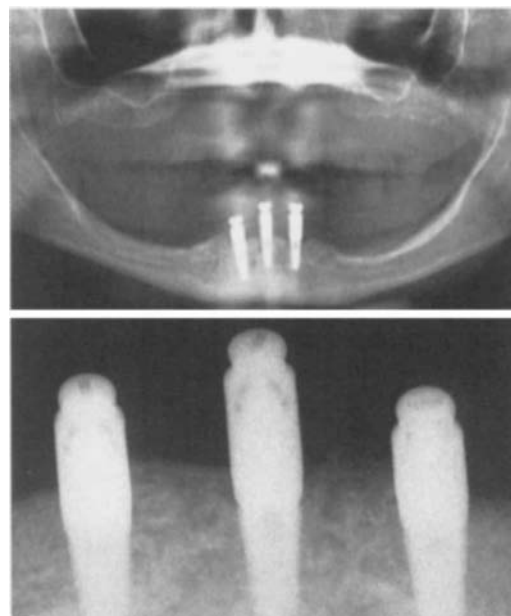
The benefits and detriments of the submerged and semi-submerged options have been discussed throughout this chapter. Fully protected afunctional healing is of prime importance to achieve osteointegration, regardless of which protocol is used. The benefits of semi-submerged healing are valuable in cases in which no early provisional removable prosthesis is required for esthetics, or in cases that use a provisional prosthesis that can be provided with no less than 1 mm of clearance directly over and around each healing collar. Whether the submerged or semi-submerged protocol is followed, the patient must be placed on a soft diet and instructed not to chew anything at all on the side under treatment. The submerged option requires a second surgery to expose the implant. This in turn necessitates an additional visit 7 to 10 days later for suture removal.

Sequencing of Transfer Coping Impressioning

The timing of transfer coping impressioning within the treatment protocol is not standard throughout the discipline. This chapter was written advocating direct bone impressioning on the day of implant exposure, not on the day of implant insertion as in the teaching case in Chapter 10. One benefit is that this protocol can be used for either the **solo** or **team approach**.

Another benefit of impressioning on the day of implant insertion is that the required cementable implant abutments, provisional teeth, and even the final casting and bisque bake for the planned tooth restorations can be prepared by the laboratory during the long period of bone healing required of root form implants. This reduces total elapsed treatment time, the number of patient visits, costs, and prosthodontic complexity. Many practitioners are unfamiliar with the concept of immediate impressioning, and fear displacement or even removal of the inserted implant as the elastic impression over the copings is removed. However, the fact that the transfer coping fixation screws can be

FIG. 11-42 ■ Radiographs of implant insertions for overdenture case. (Courtesy Alfred Heller, Worthington, Ohio.)



removed from their transfer copings intraorally before the direct impression is removed facilitates direct impression removal, with little or no possibility of implant disturbance.

When immediate impressioning is not performed, as in the teaching case in this chapter, the solo practitioner takes the transfer coping impression for fabrication of the prosthodontic master model on the day of implant exposure, after healing. This is either done when healing collars are removed if the semi-submerged treatment protocol is followed, or following implant exposure and removal of cover screws if the submerged healing protocol is followed. Healing collars are placed, and the case is sutured. In the case of the team approach, the insertion practitioner exposes the implants, removes the cover screws, and places the appropriate healing collars. The patient is referred back to the restorative practitioner for removal of healing collars, setting of transfer copings, impressioning and bite registrations, and replacement of the healing collars. Any adjustments to case sequencing are made as required.

Expanded Restorative Procedures

Rather than placing an individually supported crown on each of the three implants in the teaching case, some practitioners would recommend the use of two implants restored with a three-unit fixed prosthesis, with a middle tooth pontic. Because of the unusual efficiency of the microsphere interface, the center implant inadvertently can be placed in a state of hypofunction if three implants are splinted, resulting in undue bone loss. The concept that one can have excessive bone support takes some getting used to, but in the final analysis, this is an excellent problem to have. Some practitioners compensate for the efficiency of these implants by fabricating a three-unit splinted restoration and using a shorter implant configuration in the central position.

Implant Insertion in New or Partially Healed Extraction Sites

In mainstream cases, immediate insertion of an implant into an extraction site can be performed providing that the tooth socket is obliterated during osteotomy preparation and any infection or inflammation, if present, is minor and under antibiotic treatment.

Precision and Semi-Precision Attachments

Precision or semi-precision attachments are only recommended when inverted and used in conjunction with natural co-abutments. When natural co-abutments, which have resiliency, are used in this way, the attachments prevent the teeth from acting as cantilevers off the implant abutments. **Stress breakers** may help achieve the same result. These procedures are at the edge of mainstream and are rarely used.

Screw Retention

The main benefits of **screw retention** are re-entry if complications arise, and dependable prosthesis fixation when minimal occlusal clearance does not provide for adequate cementation area because of shortened abutments. Given the excellent survival rates of root form implants, some practitioners believe that the use of screws for retention is not warranted. Loose or fractured screws are complications that should be avoided if possible.

Mandibular Edentulous Arch and Overdenture Restoration

As few as three anterior mandibular implants can support a complete arch overdenture (Figs. 11-42 and 11-43). Thus, in cases in which the anatomic presentation does not al-

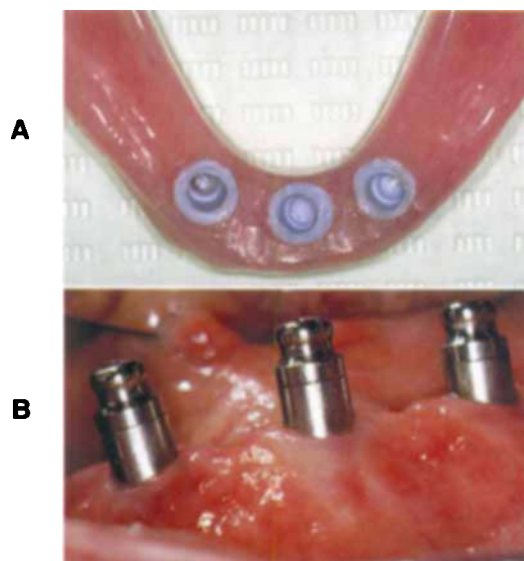


FIG. 11-43 ■ Tissue surface of overdenture with retention mechanism (A) and overdenture abutments (B). (Courtesy Alfred Heller, Worthington, Ohio.)

low for the placement of four implants, or when one implant must be removed because of an irreversible complication, a complete arch overdenture nonetheless often can function long-term.

Root Form and Plate/Blade Form Co-Abutments

Some practitioners have achieved acceptable results using a combination of plate/blade forms and root forms under a prosthesis. In almost all of these cases, the edentulous area encompasses everything distal to the cuspid. In the mandible, a root form is inserted in the first premolar area and a two-stage osteointegrated plate/blade form is inserted over the inferior alveolar canal. The practitioner sequences the case for osteointegration of the plate/blade form. Such cases are not considered mainstream.

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12 Root Form Implants

Treatment of Anterior Single-Tooth Edentulism Diagnosed for a Fixed Prosthesis

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BENEFITS AND DESCRIPTION OF THE MODALITY AND SYSTEM USED IN THE TEACHING CASES

This chapter describes patient selection, diagnosis, treatment planning, and case sequencing for the treatment of anterior single-tooth edentulism with a root form implant (Fig. 12-1).

Currently, the most commonly used root form configurations are threaded and parallel-sided. They have a long history of safety and efficacy. However, tapered implants are becoming more and more popular, particularly for insertion in interdental areas where protection of adjacent tooth roots and greater safety against undercut perforation during osteotomy preparation are important (Fig. 12-2).

The Friadent Frialit-2 implant system with the Frios titanium plasma-sprayed (TPS) interface is used in the teaching case to treat anterior single-tooth edentulism (Fig. 12-3). Friadent implant systems have been available for many years and are supported by more than 25 years of clinical evaluation.¹⁻³ The Frialit-2 implant system is supported by excellent clinical trials,⁴⁻⁷ one of which is presented in Chapter 8.

In mainstream cases, a Friadent Frialit-2 implant is suitable to support a single-tooth anterior restoration.

Mode of Tissue Integration

As a rule, root forms must osteointegrate to succeed in function long-term. In the teaching case in this chapter, protected submerged healing is sequenced to achieve osteointegration. Variations are shown in which the implant is inserted into an immediate extraction site,^{8,9} and in which ridge expansion is performed to increase the width of available bone to facilitate insertion.¹⁰ The afunctional healing sequence afforded by the submerged treatment protocol followed in the teaching case ensures the osteointegrated mode of tissue integration (Fig. 12-4).

Preparation for Treatment

Diagnosis and treatment planning are routine. Periapical radiographs, supplemented by panoramic radiographs if desired, are all that are required. Out-of-office radiography is not required for treatment of mainstream cases, in which ridge width is determined clinically. Special considerations during the planning stages include the necessity of proper positioning of the implant relative to adjacent tooth roots, correct axial inclination to remain between the labial and lingual cortical plates of bone, sufficiently labial positioning of the implant for proper esthetics and occlusion, and in the case of implantation in the area of the maxillary central incisor, avoiding impingement upon the anterior palatine foramen. A preinsertion positioning stent may not be required in view of the wealth of tooth structure landmarks for guidance. A commitment to follow rigorously the treatment protocols outlined in this chapter is important to promote predictability and success.

Technique-Permissive Implant Insertion

The technique of inserting the implant is straightforward and easily mastered. The treatment protocol is critical but easy to follow. This protocol ensures the desired mode of tissue integration by applying the appropriate case sequencing to ensure afunctional healing and long-term stability.

Proven Long-Term Success/Survival Rates

More research has been devoted to the root form modality than to any other implant modality. It is widely understood to be safe and effective for its intended purpose of providing abutment support for prosthodontic restoration. Seminal studies related to this modality, and one of the clinical trials specifically on IMZ/Friadent implants,¹¹⁻¹⁴ are analyzed in Chapter 8.



FIG. 12-1 ■ Fractured right maxillary incisor.

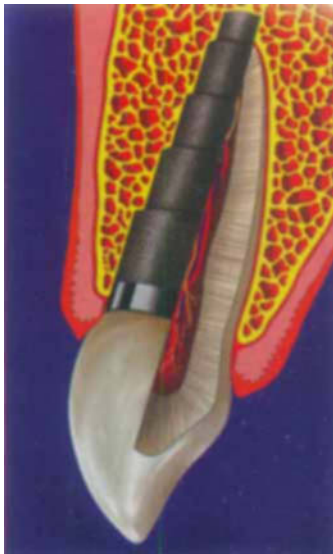


FIG. 12-2 ■ Implant positioning.

Unique Features

The Friadent Frialit-2 implant system¹⁵ is available in four diameters, each with three or four lengths. Each diameter of implant is color-coded with its respective components and instruments. The color coding minimizes confusion and simplifies setup. Friadent Frialit-2 implants are available with the Frios interface coated with titanium plasma spray (TPS) or hydroxyapatite (HA), or given the grit blasted/acid etched deep profile surface (DPS) (Fig. 12-5). The TPS interface (Fig. 12-6), used in this chapter, and the DPS interface are described comprehensively in Chapter 4. The implant system includes unique components for esthetic temporization, gingival formers, transfer copings and caps for precise impressioning for master model fabrication, and abutment choices for improved esthetics of final restorations and increased versatility. Torque drivers for easier handling and precise screw tightening complete the prosthodontic aids. A series of color-coded twist, round, and graduated stepped drills with depth stops are available for osteotomy preparation, as are bone compactors that can be used for ridge expansion. Additional specialized components not described in this chapter are



FIG. 12-3 ■ Friadent Frialit-2 stepped, tapered implant with the Frios titanium plasma-spray interface, used in the teaching case in this chapter.

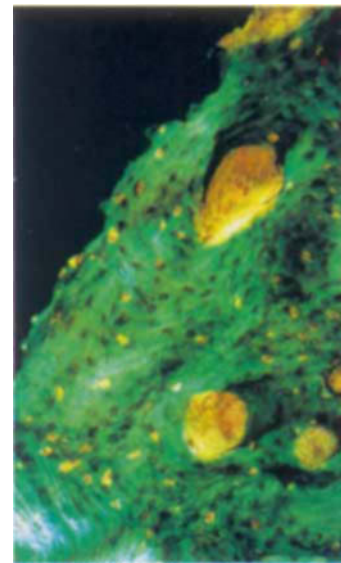


FIG. 12-4 ■ Light microscopy. Direct bone apposition at the implant interface.



FIG. 12-5 ■ Friadent Frialit-2 implants with Frios hydroxyapatite (HA) (left), titanium plasma spray (TPS) (center), and grit-blasted/acid-etched (DPS) (right) interface treatments.

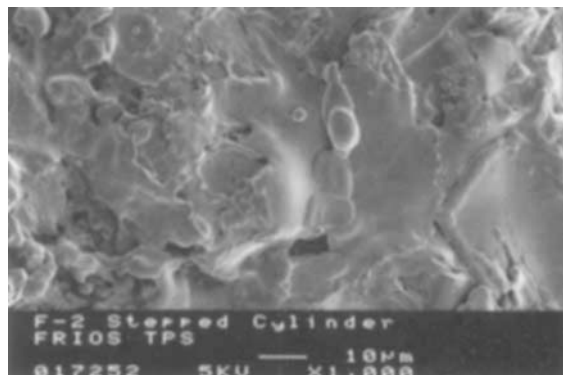


FIG. 12-6 ■ Electron micrograph of Frios titanium plasma spray (TPS) interface.



FIG. 12-7 ■ Abutment options not used for the teaching case in this chapter. A, Cerabase. B, Auro Base. C, Telescopic. D, Ball and socket.



FIG. 12-8 ■ Friadent Frialit-2 deep internal hex (*left*) and long parallel walls (*right*).



FIG. 12-9 ■ Friadent Frialit-2 implants in various diameters and depths.



FIG. 12-10 ■ A selection of gingival formers.



FIG. 12-11 ■ ProTect provisional abutment (*left*) in various color-coded diameters (*right*).

available to accommodate various other treatment planning possibilities (Fig. 12-7).

Configuration and Nomenclature of the Implants Discussed in This Chapter

The stepped root form implants used in the teaching case, 3.8 and 4.5 mm in diameter and 13 mm in length, have deep internal hex abutment receptors to prevent rotation, and parallel walls to better distribute lateral forces (Fig. 12-8). The length of engagement between the implant and abutment is 3.5 to 5 times that of the standard external hex. Each implant is supplied with a placement head and a titanium flat sealing screw.

Implants are available in depths of 8, 10, 11, 13, and 15 mm, and in diameters of 3.8, 4.5, 5.5, and 6.5 mm (Fig. 12-9). Gingival formers are available for use following implant exposure. They are color coded and supplied in all coordinated diameters, in depths of 2, 3, and 5 mm to accommodate variations in gingival thickness (Fig. 12-10). The gingival formers are not needed when ProTect provisional abutments are used.

ProTect provisional abutments are available in all diameters, each with a guide pin and abutment screw (Fig. 12-11). Transfer copings for the open tray pick-up technique or closed tray transfer technique are available with transfer caps and implant analogs, all color coded and in coordinated diameters (Fig. 12-12). MH-6 straight and angled color-coded

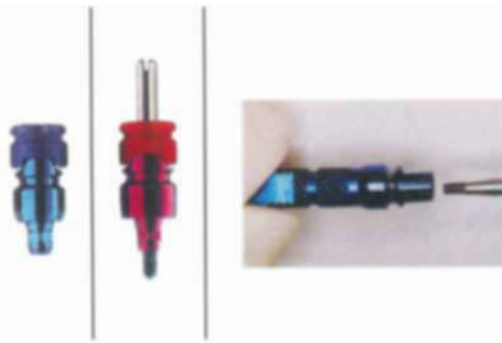


FIG. 12-12 ■ Transfer copings and caps for closed tray technique (*left*), open tray technique (*center*), with attached implant analog (*right*).



FIG. 12-14 ■ A missing maxillary central incisor.

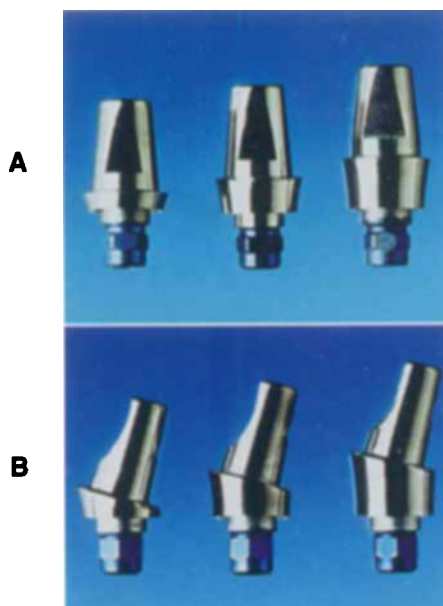


FIG. 12-13 ■ A selection of straight (A) and angled (B) MH-6 abutments.

coordinated abutments are available for the prosthodontic regimen (Fig. 12-13).

TYPICAL MAINSTREAM CASE—DIAGNOSIS, TREATMENT PLAN, AND END RESULTS

Case as Presented

Patient's Story. A typical mainstream case presents with an anterior maxillary tooth in need of extraction, or previously extracted. It is preferable that the adjacent teeth be in good health and esthetic. Further, it is preferable to treat one's first few cases in the presence of acceptable occlusion.

The patient and practitioner hope to avoid the reduction of the adjacent teeth that would be required to support a fixed prosthesis, and a removable prosthesis is not desired. Esthetics that conceal the artificiality of the proposed restoration are a must.

Clinical Appearance. An anterior troubled or missing tooth compromises one's ability to function socially (Fig.



FIG. 12-15 ■ Preextraction radiograph.

12-14). Therefore, this condition requires immediate attention. In mainstream cases, the gingival lineup of the adjacent teeth is within normal limits. If an edentulous area is present, adequate room is available for ideal prosthetic replacement, and the crestal height of the residual ridge following healing or tooth removal is resorbed no more than 5 mm compared with the ridge at the adjacent teeth. Labio-lingual width, if a tooth requires removal, can be maintained by the immediate insertion of an implant, and in mainstream cases with healed ridges, the labio-lingual width is either adequate or can be made adequate with conservative ridge expansion techniques.

Radiographic Interpretation. The periapical radiographs reveal adequate depth of available bone from the ridge crest to the floor of the nasal cavity for the insertion of an implant of sufficient depth to withstand anticipated functional loads long-term within physiologic limits of health. The landmarks and osseous borders are clearly observed on the preextraction radiograph (Fig. 12-15).

BOX 12-1 ■ VISIT-BY-VISIT TREATMENT**OBJECTIVES**

Preoperative procedures

Visit 1: Implant insertion, first provisional restoration

Visit 2: Suture removal

Visit 3: Implant exposure, tissue impression, second provisional restoration

Visit 4: Healing evaluation

Visit 5: Bisque bake try-in

Visit 6: Cementation of completed crown

Rejected Alternative Treatment Plans

The status quo is clearly unacceptable. The patient will not consider a fixed bridge that requires the preparation of good natural teeth. For reasons of esthetics, comfort, and social acceptability, a removable partial denture is also rejected. For these reasons, a root form–supported single-tooth fixed replacement is the treatment of choice.

Accepted Treatment Plan—Visit-By-Visit Case Sequencing and Timing

The objectives of each of the treatment visits for the teaching case in this chapter are shown in Box 12-1. It is important to have a basic understanding of the entire course of treatment, so that one can appreciate how each procedure contributes to the ultimate success of the case.

Completed Case

Having the goal of treatment firmly in mind during each patient visit is important. Every step in each procedure is directed toward successful completion of the case. For this reason, the end result is presented now, to help the reader understand how each treatment step contributes to the final result, and to convey the satisfaction and benefits of treatment to the patient and the practitioner.

Patient's Story. The treatment goals have been achieved. The replacement is fixed, esthetic, undetectable, comfortable, and functional. The patient is at ease socially, and can speak and laugh without being self-conscious.

Clinical Appearance. The prosthesis is carefully matched for shade. Gingival contours are harmonious. Interproximal papillae are present. The replacement is not readily detectable. This type of case represents an enormously important service to the patient.

Radiographic Interpretation. A postoperative radiograph of the completed case reveals a well-positioned implant, correctly related to the adjacent tooth roots, sufficiently deep and yet not impinging on the floor of the nasal cavity. The abutment is correctly seated within the implant (Fig. 12-16).

Microscopic Interpretation at the Interface. Following healing, light microscopy reveals fine bone apposition at



FIG. 12-16 ■ Postoperative radiograph showing an ideal result.

BOX 12-2 ■ PREOPERATIVE PROCEDURES

Quantification of available bone

Selection of implant configuration

Consideration of implant positioning options

Preoperative medication

Consideration of provisional restoration options

the interface, as shown in the animal histology in Fig. 12-4. The amount and distribution of direct bone apposition constitute a fine example of successful osteointegration.^{16,17}

PLANNING AND PROCEDURES BEFORE IMPLANT INSERTION

The steps that are performed before implant insertion are shown in Box 12-2.

Quantify the Available Bone

The osteointegration mode of tissue integration is indicated in the teaching case. Quantifying available bone is accomplished following the guidelines provided in Chapters 3 and 9. To review briefly, use periapical radiographs to determine the depth of available bone between the ridge crest and floor of the nasal cavity, and to determine the mesio-distal dimension of the edentulous area between the adjacent natural teeth. Also, check carefully for any unusual pathways of natural tooth roots that may crowd the area of available bone intended for implant treatment. Palpate the labial carefully to determine whether unusual depressions or undercuts are present that could result in an osseous perforation during osteotomy preparation. Outline the “usable” available bone on the radiograph (Fig. 12-17).

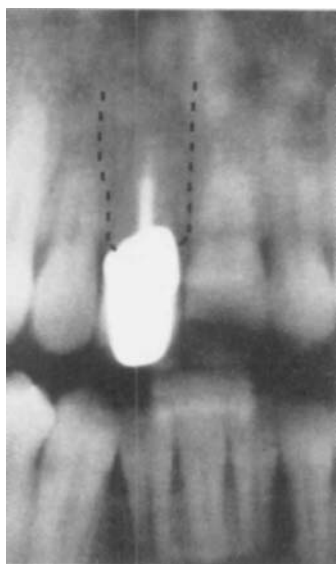


FIG. 12-17 ■ Preextraction radiograph marked to show extent of available bone.

Labio-lingual width can be determined by placing a caliper on the gingiva 1 to 2 mm from the crest. Subtract the sum of the thicknesses of labial and lingual tissue, as determined using a periodontal probe, or pass the caliper tips through the gingiva to bone.

Select the Ideal Implant Configuration for Placement Within the Available Bone

The first consideration is to be sure not to underengineer the case. In single-tooth replacement in the anterior segment of either arch, one implant must bear the entire occlusal load. Thus, anteriorly, the maximum possible diameter of implant that leaves 1 mm of bone on the labial and lingual following insertion, and maximum possible depth allowing 1 to 2 mm of clearance beyond the apex generally is used. Implants 3.8 or 4.5 mm in diameter are usually indicated. The case is well engineered when a depth of at least 13 mm can be accommodated. The prognosis is slightly more guarded when implants of 10 or 11 mm in depth are used. In the case of single-tooth replacement with the Friadent Frialit-2 implant system, one need not be too concerned with overengineering and resorption caused by hypofunction. Use the greatest diameter and depth of implant possible.

Using the measurement of available bone width obtained with calipers and depth determined by direct measurement on the periapical film, the most appropriate implant configuration can be selected. An overlay on clear plastic of life-sized replicas of various implant dimensions can be useful, although in the case of single-tooth replacement, the area of available bone is so apparent that its use rarely is required.

A deeper implant should also be ordered as a backup in case direct observation during osteotomy preparation in-

dicates that it can be accommodated. When the implant is delivered, the manufacturer's control and lot numbers are entered into the patient's record.

Implant Positioning Stent

An implant positioning stent is an effective guide for the location and positioning of a root form implant. In the case of anterior single-tooth replacement treatment, use of a positioning stent may not be required. Because the area of implantation is so confined, and so clearly defined radiographically and clinically at the time of implant insertion, the optimal pathway usually is clear to the practitioner at the time of treatment. Consider also that there are no constraints for establishing parallelism with adjacent implants, in contrast with serial placement cases with variation in bone anatomy that can compromise parallelism.

Prescribe Preoperative Medication

Prescribe preoperative medication for the insertion visit as described in Chapter 9. Keep in mind that only one implant will be inserted, so anti-edema medication should be used conservatively unless the patient has a history of greater-than-normal edema. Preoperative sedation rarely is required. Although the degree of surgical intervention is limited, patients who take daily prophylactic aspirin are asked to discontinue doing so for at least 3 weeks before the insertion visit, to permit normal clotting. Increasing numbers of practitioners now advise patients not to discontinue their aspirin regimen before being treated for single-tooth cases.¹⁸ Control of bleeding is manageable.

Provisional Restoration Options

"Flipper" Option. In cases in which the anterior single-tooth edentulous site is healed, a conventional "flipper" may already be in place, or can be fabricated in advance of the insertion visit in the customary manner. Following implant insertion and suturing, a reline with a soft material, properly relieved, may be in order.

Bonded Tooth Option. Another option is to fabricate a provisional acrylic replacement tooth of good shade and contour in advance. This provisional replacement tooth can be bonded into position against the two adjacent natural teeth. In cases of implant insertion immediately following tooth extraction, the bonded tooth option is almost always used. A study model is used for provisional replacement tooth fabrication. On the model, the tooth to be clinically removed is cut away, and the replacement tooth is fabricated in acrylic.

VISIT 1: IMPLANT INSERTION AND PROVISIONAL PROSTHODONTICS

The steps that are performed during the implant insertion visit are shown in Box 12-3.

BOX 12-3 ■ VISIT 1: IMPLANT INSERTION

Confirm use of antibiotic
 Set up instrumentation
 Perform presurgical treatment
 Administer anesthetic
 Mark osteotomy location
 Make incision
 Reflect tissue
 Reconfirm osteotomy location
 Prepare osteotomy
 Evaluate osteotomy suitability
 Insert implant
 Take postinsertion closed tray transfer impression
 Take interocclusal/opposite arch registrations
 Perform postinsertion soft-tissue procedures
 Suture
 Provide provisional prosthesis
 Provide home care instruction
 Schedule follow-up visit

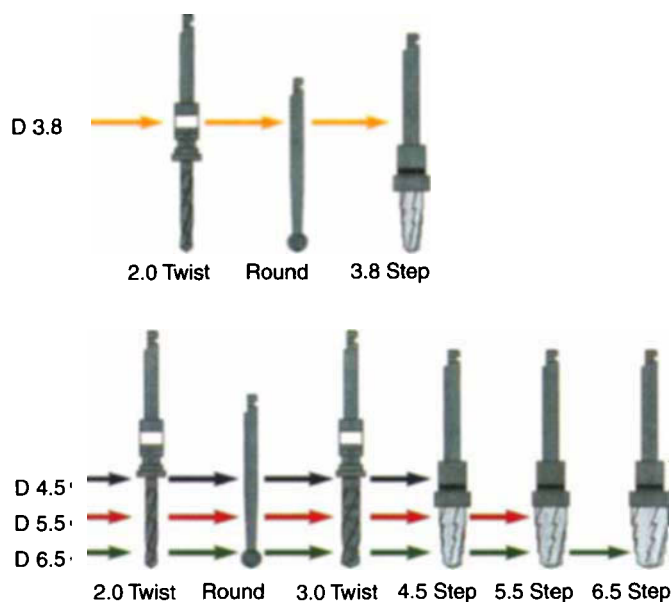


FIG. 12-18 ■ Drill guide flow chart for each of the implant diameters.

Confirm That Preoperative Medication Has Been Taken

As discussed in Chapter 9, it is not necessary to postpone a case if the patient has not taken his or her preoperative prophylactic antibiotic medication. The practitioner should have antibiotics on hand for preoperative administration in such cases. If a patient on an aspirin regimen has not discontinued its use, insertion may be performed, with delayed clotting expected.

■ Instrumentation Setup— The Armamentarium

There are two recommended surgical tray setups. The first tray, which holds the instruments that are not directly related to implant insertion, is described in Chapter 9. The second tray holds all the instruments involved with implant insertion and protection during the submerged healing protocol, as well as the implants themselves and all implant components. The loaded trays are placed side by side.

The second tray includes the selected and backup implants, each with a placement head and sealing screw; D2 twist drills (2-mm diameter in coordinated depths); a 3.8-mm round bur; D3 twist drills (3-mm diameter in coordinated depths); stepped drills 3.8 and 4.5 mm in diameter in coordinated depths (Fig. 12-18); a universal drill extender for use if added clearance of adjacent natural teeth is required to complete each drilling task; and a set of four straight bone compactors in diameters of 2, 3, 3.8, and 4.5 mm to provide for ridge expansion and bone compaction should the need arise (Fig. 12-19). A set of coordinated transfer copings and transfer caps with fastening screws for the closed tray pick-up transfer technique and mated implant analogs is also placed on the tray. A drill-

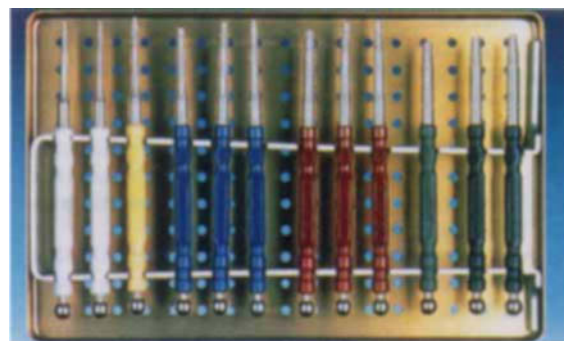


FIG. 12-19 ■ Color-coded set of bone compactors/ridge expanders.

cleaning instrument is advised. Implant seating is accomplished with the aid of a ratchet wrench, short hex driver, long hex driver, and mallet.

Presurgical Treatment

Prepare the surgical field, and administer local anesthetic that contains vasoconstrictor to promote comfort and control bleeding. Prepare the oral cavity and targeted tissues according to the principles and procedures described in Chapter 9.

Score the Bony Ridge to Mark the Planned Osteotomy Location

Consider again that the procedure is performed in a confined area, in which the main clinical landmarks are fixed in position. In healed ridges, little leeway exists in the placement of the implant from the mesio-distal point of



FIG. 12-20 ■ Transgingival ridge scoring.

view. Although many practitioners do not first score the ridge through the overlying gingival tissues, it can be helpful to do so (Fig. 12-20). The main consideration is that in the presence of adequate available bone, one does not necessarily want to place the implant midway between the teeth, because the gingival papillae that are present, which should be preserved at all cost, are not always equal in bulk or contour. For optimal esthetics, it may be appropriate to place the implant slightly off-center (Fig. 12-21). This decision should be made before the tissue is reflected.

With these considerations in mind, visualize the point of penetration for the planned osteotomy, and with a 700 XL bur in a contra angle with coolant, penetrate the gingiva and score the bone to a depth of approximately 1 mm.

Following incision and tissue reflection, this score mark guides implant positioning. The opening may then be widened with a second bur. Always consider that because of the confined area of single-tooth replacement, the score mark must not be so far off-center that it precludes insertion of the implant without danger of impingement on an adjacent tooth root. This highlights the good sense of using tapered implants for single-tooth replacement cases, or in cases in which one is in proximity to a tooth root or undercut area.

In a case that involves extraction of a tooth and immediate insertion of an implant, **scoring** the ridge is not performed. The position of the tooth root socket following removal is an absolute guide to osteotomy location.

Note in such cases that the socket is almost always slightly off-center in relation to the adjacent teeth, confirming the validity of an off-center osteotomy location when appropriate in healed ridges.

Make Incision

In a healed ridge, evaluate the attached gingiva, plan the incision line, incise in attached gingiva, and ensure hemostasis according to the principles and procedures described in Chapter 9. The extent of the incision should be

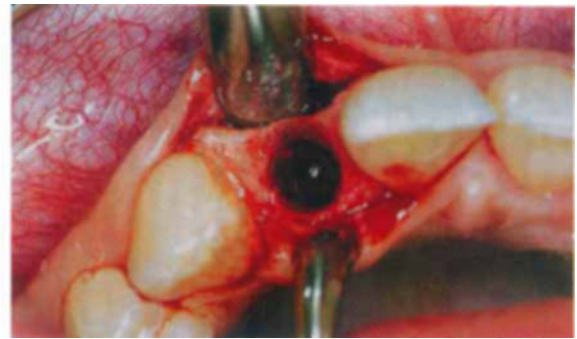


FIG. 12-21 ■ "Off-center" location of extraction socket.

between and through the gingival cuffs of the two adjacent natural teeth.

When incising the gingival papillae, be sure to turn the incision toward the lingual to help preserve their labial bulk and contour. This act alone greatly contributes to the final esthetic result.

In cases involving an extraction, delay the extraction until tissue reflection has been completed. Incise interproximally mesially and distally between the tooth to be extracted and the adjacent natural tooth, being sure to place the scalpel well toward the lingual.

This sequence enables the practitioner to control the preservation of tissue and especially the papillae, which can be injured during tooth removal.

Reflect and Prepare Tissue Before Insertion

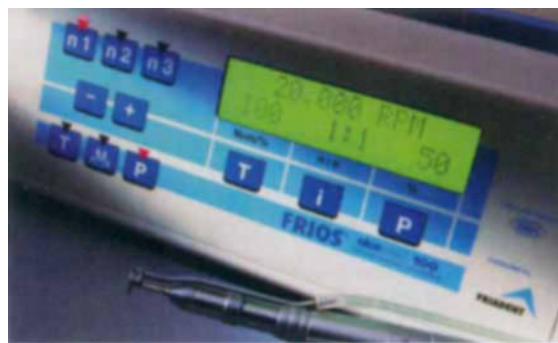
In a healed ridge or in the presence of a tooth to be extracted, reflect the tissue using a fine periosteal elevator. Start with the labial flap. Gently reach under the periosteum and lift it together with the attached papillae away from the bone to expose the labial portion of the ridge.

Because of the confined area, it is necessary to reflect tissue a few millimeters along the labial gingival margins of the adjacent teeth to promote ease of tissue reflection. This will prevent tearing of the papillae and afford better ridge exposure.

Next, reflect the lingual portion of the flap. In the area of the maxillary central incisors, identify the lateral border of the anterior palatine foramen, and try not to impinge upon it.

This tissue is thicker and firmer than the labial flap. Reflect a few millimeters along the lingual gingival margins of the adjacent teeth. Check the thickness of the crestal gingiva to confirm that it is adequate to accommodate an esthetic emergence profile.

FIG. 12-22 ■ Elcomed 100/Friadent microprocessor-controlled drilling unit.



Confirm or Change Planned Location of Implant Osteotomy

In a healed ridge case, reinspect the ridge crest and observe the position of the score mark that was made through the gingiva into bone before reflection. In anterior single-tooth replacement cases, the prime consideration is esthetics.

Room to maneuver is minimal. Thus, even if the practitioner notes a slight undercut at the planned osteotomy location, it cannot be avoided by substantial relocation of the osteotomy mesio-distally. This situation is resolved by starting the osteotomy in the preferred crestal position but angling the pathway toward the lingual. This will influence abutment parallelism, but not to a detrimental extent.

At this point, the ridge width can be viewed directly for the first time. The anatomy is carefully evaluated for confirmation of implant configuration selection. If the crest is too thin or the labial lineup not sufficiently harmonious, consider ridge expansion with bone compaction as part of the osteotomy preparation protocol.¹⁹⁻²¹

In a case involving tooth extraction, this may not be a consideration.

In a case involving tooth extraction, the extraction now is accomplished. Using an extraction forceps, the tooth, or its remaining root, is grasped gently. Do not luxate labiolingually. Most anterior teeth can be removed by turning them clockwise and counterclockwise slowly and firmly to sever the ligament fibers. Following removal, thoroughly curette and cleanse the socket.

The use of elevators to remove a tooth root is not advised, because this procedure may cause loss of valuable crestal bone. These suggestions are general; tooth removal has many possible scenarios. Whatever the circumstance, retention of bone is always a priority.

Observe the crestal thickness of the gingiva, and determine now if insufficient tissue depth may cause esthetic problems with the emergent profile. If so, appropriate

treatment is described in this chapter in the section that discusses complicating and atypical conditions.

Implant Osteotomy Preparation in a Healed Ridge

Basic Considerations of Osteotomy Drilling. All osteotomy drilling is performed with copious coolant to control temperature. A high-quality, low-speed, high-torque drilling unit with automatic control of speed, torque, and coolant is required (Fig. 12-22). Follow the drilling speed protocols to prevent damage to bone. Avoid excessive pressure. Drilling must be intermittent. Stop frequently to withdraw, cleanse, and suction the area. Place the suction tip at the edge of but not directly over or into the osteotomy.

In a healed ridge, the osteotomy for a 3.8-mm diameter implant is created using three drills. The D2 twist drill, 2 mm in diameter, establishes the appropriate angle, width, and depth of the pathway to guide the coordinated round bur and stepped drill in the final formation of the osteotomy. A drill guide for the 3.8- and 4.5-mm Friadent Frialit-2 Stepped Root Form Implants is illustrated in Fig. 12-18.

The score mark sets the point of initial entry on the ridge crest. It also stabilizes the drill position for initial bone penetration.

Twist Drill Pathway. The D2 twist drill does not create the final shape of the osteotomy. Nonetheless, it is best to mentally establish as accurately as possible the labiolingual and mesio-distal angle at which the drill will be held as it penetrates bone.

Every effort is made to be accurate at every step of the procedure to obviate the need for corrections at later stages. Attempt to visualize the desired long axis of the implant within bone. Consider adjacent tooth roots, parallelism, and the planned position of the labial extent of the osteotomy at the ridge crest, and avoid any undercut that may be present to prevent perforation.

The next step is to drill at the recommended speed of 800 to 1000 revolutions per minute (rpm) to the appropriate implant depth, which is 13 mm in the teaching case. The 13-mm D2 twist drill has a depth stop to prevent over-

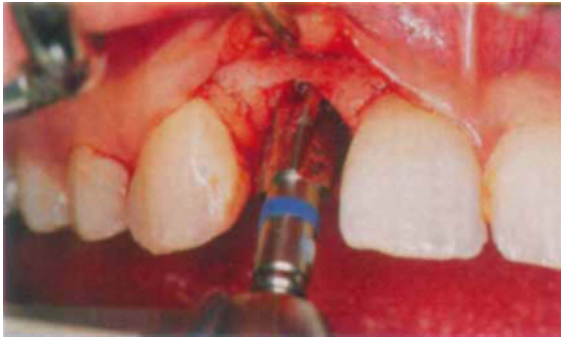


FIG. 12-23 ■ Coordinated stepped drill completes osteotomy.

penetration and possible injury. The drill is removed, and the site cleaned, suctioned, and checked.

Check the path of insertion and that the desired depth has been reached.

Use of the Round Drill. The 3.8-mm round drill now is positioned at the crestal opening of the completed D2 twist drill pathway. Rotate it slowly until its widest diameter is flush with the ridge crest. Remove, cleanse, and suction.

This action bevels the opening to further stabilize the 3.8-mm step drill when it is used.

Completion of the Implant Osteotomy. To prepare the final osteotomy for a 3.8-mm diameter implant in a healed ridge, the D3.8 stepped drill, 13 mm in depth with a depth stop, is positioned at the ridge crest. This bur is of precise dimensions to ensure a firm frictional fit when the implant is seated.

Before drill activation, angle the long axis of the drill as accurately as possible to follow the pathway established with the D2 twist drill.

Hold the drill steady and true, and at the recommended speed of 800 to 1000 rpm, complete the osteotomy to the depth stop (Fig. 12-23). Remove, cleanse, and suction.

Note that the drilling speed using the stepped drill is as controlled as when using the twist drill. Every effort is made to control heat production. Intermittent drilling in the established pathway axis, low pressure, and repeated cleansing are always recommended.

Additional Step Required for Osteotomy Preparation for a 4.5-mm Stepped Cylinder. To review, in the case of 3.8-mm stepped cylinder osteotomy preparation, the drilling sequencing is a D2 twist drill (2 mm in diameter), a round bur (3.8 mm in diameter), and then a stepped drill (3.8 mm in diameter).

In the case of a 4.5-mm stepped cylinder osteotomy, following the use of the 3.8-mm diameter round bur, a second twist drill is used to enlarge the pathway. A D3 twist drill, 3 mm in diameter and 13 mm in depth with a depth stop, is set into position at the ridge crest. Commence drilling in the same manner as when using the D2 twist drill, and bring the penetration to its final depth. Remove, cleanse, and suction.

Again, visualize the position desired within bone before starting to drill. Hold steady and true during drilling.

To complete the 4.5-mm stepped cylinder osteotomy, a 4.5-mm diameter stepped drill of 13 mm depth with a depth stop is used in the same manner as previously described for the 3.8-mm stepped drill.

Note again that the entire protocol is carefully controlled. Every step is carefully performed and checked to ensure that subsequent steps can be performed successfully. In this way, one can always know exactly why a problem occurred and to what step in the procedure it is related, so it can be corrected immediately.

Implant Osteotomy Preparation Following Tooth Removal

Basic Considerations of Osteotomy Drilling. A stepped implant 4.5 mm in diameter typically is used in this type of case. Following tooth removal, inspect the crest of the remaining bone, especially labially. Its height should be within 5 mm of that of the adjacent bone on either side to ensure harmony of gingival contouring among the anterior teeth and the single-tooth replacement. If it is greater than 5 mm, the chance of a harmonious esthetic result is diminished.

Inspect the socket and preoperative radiograph to fix in mind the amount and variation of available bone mesial and distal to the socket. Clinically evaluate the labial extent of the opening, which is most often closer to ideal than that found in healed ridges that have undergone some resorption.

Twist Drill Pathway. Creation of a twist drill pathway, described for treatment of a healed ridge, is not applicable in a case involving tooth extraction. The pathway is determined by the socket. However, with a D3 twist drill of coordinated depth, measure whether the socket depth reaches the 13 mm required for the selected implant configuration. If necessary, use the D3 twist drill to deepen the socket to the depth of the implant.²²

The socket usually is short of that depth if the implant was selected according to the principles described in Chapters 3 and 9.

Completion of the Implant Osteotomy. The appropriate stepped drill, in this case 4.5 mm in diameter, is



FIG. 12-24 ■ Double glass vial “no-touch application system.”



FIG. 12-25 ■ Clinical view (A) and radiograph (B) of seated implant.



FIG. 12-26 ■ Seating of closed tray transfer coping and cap.

now used as previously described. This drill obliterates the socket and carries the osteotomy to its final depth. Cleansing and suctioning are performed before the next step.

Evaluate and Test Prepared Osteotomy

The supplier does not provide trial fit implants to check the osteotomy before seating. The depth stop on the stepped drill, coupled with careful drilling, helps ensure accuracy. Some practitioners test the osteotomy using a coordinated bone compactor. If necessary, the compactor can

be tapped with a mallet to bring the osteotomy to its correct depth.

Final Seating of the Implant

The implant is removed from its sterile packaging by snapping the implant driver into the adapter screw on top of the implant. The implant is withdrawn from the inner vial (Fig. 12-24) to be placed into its prepared osteotomy.

The fine packaging concepts of this system complement one's efforts to maintain sterility of the implant at each step of the procedure.

When the implant is placed into the osteotomy, the driver is unsnapped and an implant seating instrument is carefully positioned to nest snugly into the adapter screw supplied with the implant, such that the long axis of its handle is parallel with that of the implant. With several sharp taps, the implant is malletted to its final position (Fig. 12-25). The adapter screw is removed with a 0.9-mm hex-driver.

If the coronal edge of the implant is not entirely below the ridge crest, tap again with the mallet. Do not remove the implant once it has been malletted into position.

Immediate Postinsertion Impressions/Model Fabrication

Placement of Transfer Coping and Cap. Using an MH-6 seating instrument, a color-coded coordinated transfer coping with a coping screw is inserted into the interhexagon of the implant. The transfer coping is used together with a transfer cap (Fig. 12-26) for ease of reseating into the transfer impression. Cleanse the area.

The assembled configuration can be accurately seated into the impression in the model-making protocol.

Direct Bone Impressioning. To supply the laboratory with the information it needs to fabricate an accurate model, a direct bone impression is taken using the closed tray pick-up transfer technique, preferred here because of the use of a single implant.

The open tray transfer technique, slightly more complex, is preferred for cases of serial implant placement, where lack of parallelism can cause a removal problem.

Any accepted elastic impression material may be used, preferably the one used for one's conventional crown and bridge procedures. Many practitioners use vinyl polysiloxane. The direct bone impression is made as one would for a prepared natural tooth to fabricate a conventional crown

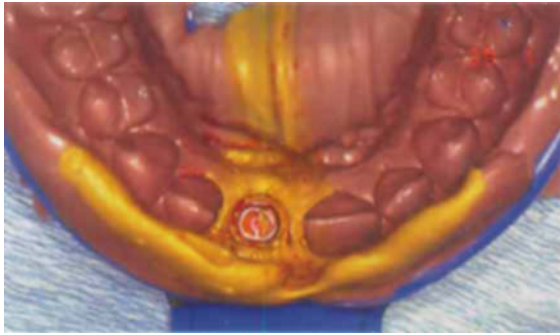


FIG. 12-27 ■ Closed tray vinyl polysiloxane impression.



FIG. 12-28 ■ Suturing for closure.

model (Fig. 12-27). The transfer cap lifts off its coping and remains within the impression as it is removed.

The two flat, parallel surfaces on the transfer coping exactly transfer the required seating position of the hexagon. A circumferential groove ensures that it is positioned accurately in the vertical relationship.

The impression is removed. Removal of the abutment screw with an MH-6 seating instrument allows for removal of the transfer coping. The area is cleansed and suctioned. The impression with the transfer cap, transfer coping, and abutment screw are set aside.

Place the Sealing Screw. After the transfer assembly has been removed, a flat sealing screw is placed on the implant to prepare for interocclusal/opposite arch registrations.

Interocclusal/Opposite Arch Registrations

A study model of the opposite arch is used at this time. It can be duplicated or clinically reimpressioned as desired. Following removal of the transfer assembly and setting of the sealing screw, an interarch registration is recorded before tissue closure, in cases in which hand articulation is not possible. After fabrication, removing the transfer assembly from the implant analog in the laboratory model allows seating of this bite to relate the opposing models for articulation. The articulated models then are used for fabrication of a provisional ProTect abutment and crown combination and a bisque-baked or final crown over a selected and adjusted MH-6 angled abutment.

It is preferred that bite registrations and counter models be obtained according to whatever procedure is commonly used in one's conventional office routines.

When these procedures are complete, the area is again cleansed and suctioned.

Postinsertion Soft-Tissue Procedures

Remove excess tissue, if any, that may interfere with proper closure. If lingual tissue is too thick, thin it out according to the principles outlined in Chapter 9. When the soft tis-

sue is ready for suturing, take a periapical radiograph for the patient record.

Final Closure—Suturing

Suture according to the principles and procedures described in Chapter 9. Suture to ensure the presence of attached gingiva following healing and the best possible formation or appearance of interproximal gingival papillae (Fig. 12-28).

Carefully considered plastic surgery now will go a long way to ensure an esthetic final result. The value of bringing the initial incision toward the lingual at each interproximal area is evident at this time. Note the position of gingival papilla following suturing. Add sutures for improvement, if necessary. In cases involving tooth extraction, undermining additional flap and/or making a relieving incision to enable tissue coaption may be necessary. The implant is submerged for healing.

Provisional Prosthesis Options

“Flipper” Option. A flipper used by the patient before treatment may be used for provisional restoration, or a new one may be fabricated in the conventional manner for use now. Seat it, adjust the occlusion and esthetics if required, and reline with a soft material. Adjust such that as little tissue contact as possible occurs directly over the implanted area.

Bonded Tooth Option. In cases involving tooth extraction, and often in cases of healed ridges, the bonded tooth option is the technique of choice. The laboratory fashions an acrylic replacement tooth on a duplicate of the study model, unaltered in the case of a healed ridge, and altered by cutting away the tooth to be removed in a case involving tooth extraction. Shape, color, and projected gingival contour are all factors in creating an esthetic result.

The replacement tooth now is manually positioned between the adjacent natural teeth and gently against the sutured ridge. The gingival height and contour are adjusted as required, and the interproximal areas are shaped to accommodate and not impinge on what are to be the final papillae. In some cases, relining may be required. Avoid tissue con-

FIG. 12-29 ■ Provisional restoration bonded into position.

tact directly over the implant. Polish away approximately 0.25 mm at the tissue surface of the provisional crown.

Holding the tooth in position as best as possible, have the patient close in centric and make gross adjustments. Repolish, and prepare the proximals for bonding to the adjacent teeth.

Note the details of this procedure. It is important to be able to dismiss the patient after this insertion visit with the best possible esthetics, albeit provisional. This is much appreciated and a fine practice builder.

Using the conventional bonding techniques one uses for routine office procedures, carefully bond the provisional restoration into position. Treat the adjacent teeth as conservatively as possible. When securely bonded into position (Fig. 12-29), make final occlusal adjustments in all excursions, repolish, and cleanse the area.

Postinsertion Home Care Instruction

As discussed in Chapter 9, advise the patient about the effects that can result from the trauma of the surgery, and prescribe prophylactic antibiotic and analgesic medications. Instruct the patient in proper postoperative cleanliness, and advise him or her to maintain a soft diet. Tell the patient to avoid chewing in the implant area to ensure that tissue integration will not be interrupted and to prevent dislodgment of the bonded provisional teeth.

If the “flipper” option is chosen, the patient is advised that the flipper may be removed for cleaning but should be quickly replaced to avoid edema that could interfere with fit.

Postinsertion General Considerations

In cases of normal healing, to comply with conservative case sequencing, the next appointment is made an average of 4 months after suture removal in the mandible, and 6 months after suture removal in the maxilla.

These healing periods allow for sufficient direct bone apposition to the implant interface, which is the object of the functional osteointegration planned for. The overlying soft tissue will also be completely healed.

BOX 12-4 ■ VISIT 2, WEEK 1: POSTINSERTION FOLLOW-UP VISIT

Perform general evaluation
Remove sutures
Evaluate soft-tissue healing
Check provisional prosthesis and adjust, if required

BOX 12-5 ■ RESTORATIVE PROCEDURES (DURING 24-WEEK HEALING PERIOD)

Create and articulate master model
Adjust selected provisional abutment
Fabricate second provisional restoration

Following the 4 to 6 months of healing, the patient is scheduled for implant exposure.

Visit 2: Postinsertion Follow-Up Visit—Suture Removal

The steps that are performed during the postinsertion follow-up visit are shown in Box 12-4.

As described in Chapter 9, a postinsertion follow-up visit is scheduled for 7 to 10 days after implant insertion. At this time, conduct a general evaluation, remove the sutures, evaluate soft-tissue healing, and check and adjust the provisional prosthesis.

RESTORATIVE PROCEDURES

The steps that are performed during the restorative procedures are shown in Box 12-5.

General Considerations

Implant insertion is complete, and the immediate postinsertion provisional restoration is in place. The master direct bone impression, counter model, interocclusal bite registration, transfer coping/cap assembly with its abut-

ment screw, and implant analog have been set aside and are available.

At this point, treatment options vary, depending on an assessment of potential complications that may need to be addressed to obtain acceptable esthetics. Although single-tooth replacement is considered mainstream, it is among the more demanding mainstream procedures. The procedure is highly detailed, and the considerations are many. Basic to all decisions is soft-tissue evaluation. If tissue depth is sufficient to develop an acceptable emergence profile as the replacement tooth passes from a well-positioned implant into the oral cavity, and if sufficient gingival papillae are present, one may consider fabricating a final replacement on the abutment selected using the master model implant analog. Given such ideal tissue, one eventually must be able to expose the implant in a delicate and conservative manner, and trim tissue as needed, so that after seating the final abutment and fastening the final restoration to it, the tissue will heal as predicted. In most cases it is advisable to proceed more deliberately, and test esthetics at each step.

The master model is poured and articulated for use in fabricating the second provisional single-tooth replacement. This usually is done at the laboratory during the 4- to 6-month healing period, and returned for use at the time of implant exposure.

Creating and Articulating the Master Model

Pouring the Master Model. The master model usually is poured at the laboratory. First, using the supplied abutment screw, the transfer cap within the impression is assembled to its color-coded coordinated transfer coping. The implant analog then is attached to the transfer coping, and the transfer assembly/analog is carefully seated into the transfer cap in the vinyl polysiloxane impression, lining up the flat surfaces of the transfer coping and transfer cap. A circumferential groove on the transfer assembly helps ensure vertical accuracy. The master model of the direct bone impression is poured, trimmed, and cleansed.

Articulating the Master Model. Using the bite registration, the master model and its counter model are mounted on an articulator in the desired relationship.

Remember at this point that there is no soft-tissue representation on this direct bone model. The adjacent natural teeth and the implant analog, which establishes the position of the inserted implant in the edentulous area, are accurately recorded.

Fabrication of the Second Provisional Single-Tooth Replacement

Selection and Preparation of the Provisional Abutment. The ProTect provisional abutment is used in the teaching case. An esthetic cement or screw-retained provisional tooth replacement can be fastened to this provisional abutment, which also acts as a gingival former.²³ It



FIG. 12-30 ■ ProTect provisional abutment seated in direct bone impression master model.

too is color-coded to coordinate with the implant. In the teaching case, a provisional cement-retained single-tooth replacement is used. The ProTect provisional abutment now is seated into the implant analog.

Recall that in the maxilla, and particularly in the anterior maxilla, the long axis of the implant body placed within the confines of the available bone most often does not conform with the long axis of the planned single-tooth replacement. Parallelism must be achieved by preparation of the abutment head, or in extreme cases a custom-made abutment can be fabricated to solve this problem.

In most cases, the laboratory or the practitioner now prepares the coronal portion of the ProTect provisional abutment to provide occlusal clearance and parallelism. This can mean reduction of coronal material or addition to it, as required. Undercuts and grooves are obliterated.

Customization of Soft Tissue. The master model has no soft-tissue representation on it. With the ProTect provisional abutment as initially adjusted in position on the master model (Fig. 12-30), wax up the desired ideal gingival contours and papilla desired for the final result.

The provisional single-tooth replacement is fabricated to fit within the confines of the waxed-up gingival contours. In turn, when the provisional restoration is placed intraorally, it serves to guide the formation of gingival contours and papillae in imitation of the wax-up.

Fabrication of the Second Provisional Single-Tooth Replacement. The second provisional single-tooth replacement is fabricated over the prepared ProTect provisional abutment and within the gingival wax-up. The original shade that was taken is used. Every effort is made



FIG. 12-31 ■ Provisional crown on its ProTect abutment in direct bone impression master model.

to create conforming tooth contours in good contact with adjacent teeth, and just out of occlusion (Fig. 12-31).

The ProTect provisional abutment now is unscrewed from the master model and returned to the practitioner with its abutment screw and the completed second provisional single-tooth replacement crown.

VISIT 3: IMPLANT EXPOSURE AND INSERTION OF SECOND PROVISIONAL SINGLE-TOOTH REPLACEMENT

The steps that are performed during implant exposure and second provisional single-tooth replacement seating are shown in Box 12-6.

Preoperative Medication

When the submerged healing protocol is followed, the gingival tissue directly overlying the implant must be removed. Although this is a minor procedure, great care must be taken anteriorly to preserve all possible tissue, while at the same time ensuring access for seating of the ProTect provisional abutment.

Unless advisable because of other medical conditions, premedication is not required for this visit. Edema is only very rarely observed following implant exposure.

Instrumentation Setup— The Armamentarium

The tray setup for this procedure is far simpler than for implant insertion. Only one tray is needed. A coordinated disposable tissue punch color-coded to conform to the implant, a small scalpel, Noyes scissors, tissue holder forceps,

BOX 12-6 ■ VISIT 3, WEEK 24: IMPLANT EXPOSURE AND INSERTION OF SECOND PROVISIONAL RESTORATION

Administer preoperative medication
Set up instrumentation
Prepare tissue
Provide anesthesia, control of bleeding, and comfort
Record implant location
Expose implant
Test final abutment
Insert second provisional restoration
Provide home care instructions

mallet, orangewood stick, provisional cementation setup to fasten the provisional crown to the ProTect provisional abutment, an abutment screw and screwdriver to affix the ProTect abutment to the implant, hemostatic agent, mirror, and explorer are the essentials.

Other instruments of personal preference that facilitate treatment should also be included.

Preoperative Tissue Preparation

The same preoperative tissue preparation regimen performed before implant insertion is repeated, including thorough inspection of the oral cavity to locate and remove any residual food particles, thorough lavage, and application of a topical bactericidal agent.

Local Anesthetic, Promotion of Comfort, and Control of Bleeding

First, remove the flipper or the bonded provisional single-tooth restoration. In the latter case, polish the adjacent teeth. Except in rare cases in which the patient's history or medical condition indicates that special precautions should be taken, administration of a local anesthetic that contains a vasoconstrictor is sufficient. Only infiltration is required. Following administration of a topical anesthetic, the buccal fold is infiltrated over the edentulous area and the adjacent natural teeth.

Keep the anesthetic high in the fold to avoid infiltration edema as much as possible. Only a few drops need be deposited directly over the implant to control bleeding.

Recording the Implant Location

In the submerged healing protocol, try to outline the implant. Judicious use of an explorer to locate the implant can be useful. Visually, or with explorer tip penetrations, outline the circumference of the implant. Check the post-



FIG. 12-32 ■ Incisal view of exposed implant.

operative periapical radiograph for guidance. Occasionally a portion of the implant circumference may penetrate tissue during the long healing process. This is not a cause for concern.

Implant Exposure

In submerged anterior single-tooth cases, a trephine may be used. A coordinated, color-coded, disposable trephine called a “tissue punch” by the manufacturer is available. In a contra angle held such that the shaft of the trephine is parallel with the long axis of the insertion pathway of the implant, penetrate tissue down to bone at slow speed. Flush, suction, and with a small elevator and a tissue forceps, tease the circular incised tissue away from the bone to expose the implant (Fig. 12-32).

Inspect the area to identify the implant circumference, flush, and control bleeding. Only if necessary, a few additional drops of local anesthetic containing a vasoconstrictor may be used. Try not to distort the tissue.

Remove any tissue tags with a Noyes scissors. Cleanse, flush, and suction the area.

Place and Test the Final MH-6 Abutment

Preparation of the MH-6 Abutment. The MH-6 abutment is coordinated and color coded with the implant. It is supplied straight or angled, with various available heights of gingival cuff area. On the master model made at the time of implant insertion, the selected abutment is fitted to the analog. The articulator is closed in centric, and the abutment is prepared to an appropriate height and taper for interocclusal clearance and parallelism with the adjacent natural teeth. All preparation of this final abutment is carried to within 0.5 to 0.7 mm of the margin of its seating surface to the implant.

The laboratory-prepared abutment, which was returned to the practitioner with the prepared ProTect provisional abutment and second provisional restoration, is used now.

Test Seating of the MH-6 Abutment. The MH-6 abutment now is seated to the implant with an abutment



FIG. 12-33 ■ Frontal view (A) and incisal view (B) of test seating of MH-6 abutment.

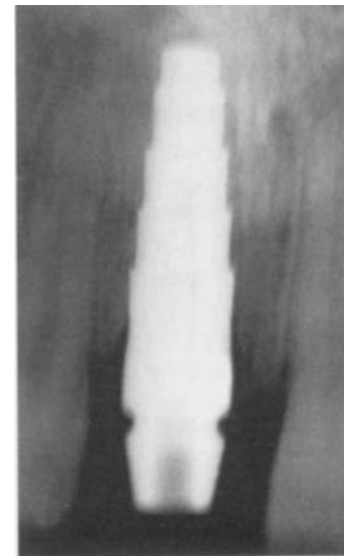


FIG. 12-34 ■ Radiograph of test seating confirms correctness.

screw (Fig. 12-33), and a periapical radiograph is taken to confirm correct metal-to-metal fit of the abutment to the implant (Fig. 12-34). Check parallelism, taper, gingival cuff height, and interocclusal clearance in all excursions.

Any necessary adjustments are made by the practitioner or by the laboratory, which is provided with detailed instructions. If the gingival cuff height of the MH-6 abutment differs substantially from what is required, a new abutment may need to be ordered.

If all is well, remove the MH-6 abutment and set it and its abutment screw aside, to be set in the implant analog for fabrication of the final tissue impression master model.



FIG. 12-35 ■ Seating of ProTect abutment clinically.

The impressing is performed following acceptable tissue healing around the second provisional single-tooth replacement, which also acted as a tissue contour former.

Insertion of the Second Provisional Single-Tooth Replacement

Fix the ProTect Abutment to the Implant Body. Inspect the exposed implant area. Recall that the direct bone impression master model was waxed up in the laboratory to the final desired tissue contour. The tissue in the mouth at this time is more confined. In screw-seating the adjusted ProTect provisional abutment, the periphery of the tissue opening may be stretched. Consider that following seating, as the abutment emerges from the tissues, its circumference becomes greater, like the circumference of a tooth. This provides for good esthetics and a proper interproximal space for each papilla.

If so much tissue is present that the ProTect abutment cannot be seated, excess tissue may need to be trimmed from the labial or lingual. In some cases, a larger trephine may be used. It is best to perform additional gingival trimming, if needed, a little at a time, trying in the ProTect abutment often. A snug fit is advised during healing.

Remember that following tissue healing, the tissues will not only be evaluated again but also a new tissue impression master model will be made that includes actual tissue contours after healing to help fabricate the most esthetic final replacement crown possible.

After all adjustments are made, control bleeding; cleanse, suction, and dry the internal receptor area of the implant; and seat and screw in the ProTect abutment with its abutment screw with 20 Ncm of force into the implant body (Fig. 12-35).



FIG. 12-36 ■ Seating of second provisional restoration.

Seat the Provisional Single-Tooth Replacement Crown. The provisional single-tooth replacement crown is fabricated of composite. It is trial seated carefully over the affixed ProTect abutment, gently stretching tissues to conform around the carefully contoured crown.

Check the occlusion and incisal lineup again. Preserve all the interproximal tissue possible to retain the added esthetics of papillae.

When all adjustments are complete, remove the provisional crown; cleanse, suction, and dry the ProTect abutment; and cement the provisional crown to it with one's provisional cement of choice (Fig. 12-36). Cleanse and suction. Re-check occlusion.

Immediate Postexposure/Second Provisional Replacement Tooth Seating/ Home Care Instructions

Trauma. The implant exposure procedure is relatively atraumatic. Postoperative edema seldom is observed. Starting on the second day, rinsing with a mild saltwater solution or chlorhexidine is advised.

Prophylactic Antibiotic Medication. Unless indicated for medical reasons, prophylactic antibiotic medication is not necessary at this time.

Comfort Medication. Comfort medication usually is not required. A prescription for ibuprofen (Motrin), 400 mg, 6 tablets, to be taken once every 4 to 6 hours if necessary, may be given to promote patient ease and confidence.

Cleanliness. After implant exposure, flossing is not advised for a few days, because it can disrupt delicate healing. Gentle lavage or rinsing is advised, starting on the second day.

Diet/Function. A soft diet is recommended. The patient is advised not to chew with the provisional restoration or otherwise put it into function.

Visit 4: Postexposure Follow-Up Visit. The patient is scheduled for the next visit approximately 3 weeks after implant exposure. Healing and the provisional restoration are checked.



FIG. 12-37 ■ Implant and healing surrounding tissues following removal of the ProTect provisional abutment.

BOX 12-7 ■ VISIT 5, WEEK 26: RESTORATIVE PROCEDURES FOR FABRICATION OF FINAL RESTORATION

Remove provisional crown and provisional abutment
 Trial seat and take radiograph of final abutment
 Take master tissue impression and bite registrations
 Remove final abutment
 Select shade
 Fabricate final master model
 Fabricate final restoration

If healing is complete, final restorative procedures can begin.

VISIT 5: RESTORATIVE PROCEDURES FOR FABRICATION OF THE FINAL RESTORATION

The restorative procedures for fabrication of the final restoration are outlined in Box 12-7.

Remove the Second Single-Tooth Replacement Provisional Crown and Its Underlying ProTect Provisional Abutment

No local anesthetic is required for removal of the provisional restoration from the ProTect abutment.

The provisional restoration guided the tissue healing to its present contours. Now is the time to check whether one's predictions about gingiva formation were accurate, and whether adjustments are necessary. If further trimming is required, do it now. One may need to trim tissue or an overcontoured area on the provisional crown. If adjustments are made, replace the provisional crown and let the area heal and adapt for a few weeks. The teaching case assumes that all went well, and no adjustments were required.

Carefully remove the abutment screw and the ProTect provisional abutment. Cleanse, suction, and inspect the implant surface and its internal abutment receptor area, and the healed surrounding soft tissues (Fig. 12-37).

Provisionally Seat the MH-6 Adjusted Abutment

This is the second seating of the MH-6 abutment into the internal receptor site of the implant. Secure it with its abutment screw.

Again check interocclusal clearance, parallelism, and taper. Also check these in relation to the healed gingival tissues for the first time. They should exhibit some semblance of papillae and a harmonious labial lineup of the gingiva with that of the adjacent teeth, and should be able to provide an emergence profile that is positioned sufficiently labially not to cause an esthetic problem.

Take Final Master Impression and Bite Registrations

Final Master Impression. Insert vinyl polysiloxane carefully into the area between the MH-6 abutment and the surrounding gingiva, down to the base of the implant sulcus, and let it set. Try not to distort the position of the tissues. Capture the surrounding teeth sufficiently to create a working model with all required information (Fig. 12-38).

Remove the impression, and check for completeness and accuracy.

Interocclusal Arch Registrations. Using the conventional methods used in one's practice, take bite registrations now.

Remove the MH-6 Final Abutment and Replace the ProTect Provisional Abutment and Second Provisional Crown

Remove the abutment screw and the MH-6 final abutment. Set them aside. Cleanse and suction. Reseat the ProTect provisional abutment and fasten with its abutment screw. Re-cement the second provisional replacement tooth.



FIG. 12-38 ■ “Tissue impression” for fabrication of final master model.



FIG. 12-39 ■ MH-6 abutment in tissue master model.

Shade and Anatomy of Final Replacement Tooth

Check and if necessary modify the original shade selected. Consider making a drawing of the replacement tooth to be fabricated. Include with the drawing important information for the laboratory, such as shade distribution, craze and/or chalk marks, and labial anatomy. In atypical cases, one may wish the ceramist to view the case directly.

Master Model Fabrication

At the laboratory, the MH-6 abutment is set to a color and size-coordinated analog. This assembly is carefully inserted into the vinyl polysiloxane impression, and a tissue master model is poured, hardened, separated, and cleansed (Fig. 12-39). Thus, the final MH-6 abutment, in this case, is also used as a transfer coping.

This model is articulated to its counter model and mounted.

BOX 12-8 ■ VISIT 6, WEEK 28: CEMENTATION OF COMPLETED RESTORATION

Remove provisional abutment and restoration
Seat final abutment
Take radiograph
Seat and adjust final restoration
Cement final restoration

Final Single-Tooth Replacement Crown Fabrication

In creating an ideal emergence profile, the laboratory should carefully consider the depth of soft tissue. MH-6 abutments are available straight (0 degrees) or angled (14 degrees) with 1-, 2-, 3-, or 5-mm collars. The appropriate choice is made based on the direct bone impression master model, and is reconfirmed now on the new tissue impression master model.

Completely ceramic restorations are preferred. They are more esthetic than porcelain-fused-to-metal crowns in that they reflect light in a manner more similar to natural teeth. Many practitioners prefer Procera All-Ceram crowns by Nobel Biocare, Yorba Linda, California. In this technique, densely sintered, pure aluminum oxide copings are fashioned with dental porcelain. This method lessens the amount of unsupported porcelain and enhances strength.

The restoration is ready for cementation.

VISIT 6: CEMENTATION OF COMPLETED RESTORATION

The steps that are performed during cementation of the completed crown are shown in Box 12-8.

Remove the second provisional crown and ProTect provisional abutment by gently unscrewing the abutment screw. Cleanse and suction.

Seat the MH-6 final abutment after thoroughly drying the internal receptor area of the implant. Screw into position with 20 Ncm of force, as shown in Fig. 12-33. Radiograph to confirm accuracy of seating, as shown in Fig. 12-34.

Try in the final restoration. Check contour, esthetics, interproximal papilla, occlusion, and color. If changes are required, the case goes back to the laboratory for correction, and the ProTect provisional abutment and second provisional crown are replaced. In the teaching case, this is not necessary. If there is any question regarding the final restoration, it should be seated for a few weeks with provisional cement.

Once everything is ideal, the final single-tooth replacement crown is cemented into position with one's cement of choice to ensure retention and color maintenance (Fig. 12-40). Periapical and/or panoramic radiographs are taken for the record. The case is complete (Fig. 12-41).



FIG. 12-40 ■ Frontal view (A) and incisal view (B) of completed case.



FIG. 12-41 ■ Radiograph of a completed case.

AFTERCARE AND MAINTENANCE— REGIMEN FOR INCREASING FUNCTION

Healing of all tissues around the implant is complete at the time of restoration. The soft and hard tissues around the implant and its components can withstand a regimen of increasing function over 2 to 4 weeks, until full function is reached. During this time, bone remodels, resulting in better function within physiologic limits of health.

The patient should notify the office if discomfort is experienced at any time, and cease function in the area until it is evaluated. The soft tissues and occlusion are checked and adjusted as required. Most often, this period of increasing function is asymptomatic.

As discussed in Chapter 9, professional and home maintenance must be performed regularly and diligently to avoid complications. Teeth with emergent profiles often have several millimeters of tissue depth from the surface to the base of the sulcus. This often is deliberately generated in the interest of improved esthetics. These teeth require excellent home care to ensure long-term function.

COMPLICATING AND ATYPICAL CONDITIONS

Common Complications and Atypical Conditions

The complicating and atypical conditions that are common to the mainstream treatment procedures using any of the abutment-providing implant modalities, as discussed in Chapter 9, are all applicable here. These include questionable adequacy of ridge width, minimal width of attached gingiva, frayed or torn flaps, excessive bleeding, retained root tip, presence of a cyst or granulomatous tissue, unusual variation in ridge height and/or contours, labial or lingual osseous perforation during osteotomy preparation, fracture of the labial or lingual osteotomy wall, friable tissue at suturing, excessive postoperative edema, and retained impression material. Each of these conditions is rare. Treating these complications properly is discussed in Chapter 9.

Inadequate Thickness of Crestal Gingiva

The concept of an emergent profile to create and control esthetics in anterior single-tooth replacement cases dictates that the depth of crestal gingiva be sufficient as measured from the bony crest, through which the final crown can flare in all dimensions to achieve the desired esthetic result. This takes 3 to 5 mm of working tissue depth. It is true that a pocket is formed in this procedure, but clinical experience shows that this pocket can be maintained in health.

If insufficient tissue thickness is encountered, crestal bone must be ramped down a few millimeters to create the necessary conditions for esthetic success. In doing this, confirm that available bone depth is sufficient to accommodate the originally selected implant after ramping, or select a shallower backup implant for the case.

Ridge Width Deficit

In a healed ridge single-tooth replacement case in the anterior maxilla, ridge width deficit is not uncommon but is easily remedied.

A series of ridge expanders/bone compactors, as shown in Fig. 12-19, is used. These color-coded instruments have the same depth indications as the implant being used. Most often, one places a score mark at the center of the planned osteotomy location. A slight ramping of the ridge crest may be needed to establish the desired 1.5-mm starting ridge width. Inspect the area, confirm score mark accuracy, and proceed.

Using a water-cooled XXL bone bur, positioned with its shaft in the long axis of the planned osteotomy, drill to a depth of 3 to 4 mm. For a 3.8-mm diameter, yellow-coded implant, choose a straight, white-coded D2.0 bone compactor. Insert the tip into the pathway started by the XXL bur, angle the handle to parallel the planned osteotomy pathway, and with a mallet slowly tap it into bone to the



FIG. 12-42 ■ Ridge compactor/expander in position during malleting.

selected depth (Fig. 12-42). Stop often, rotate but do not remove the instrument, and tap again. When the final depth is achieved, remove the instrument. Should cortical bone prevent insertion to the desired depth, remove the instrument and use a D2 twist drill to penetrate the dense area. Reinsert the bone compactor and continue the procedure. Always maintain the desired path of insertion. At final depth, change to a D3 bone compactor, and slowly and gently repeat the process to the desired depth. The bone will expand gently. If the labial edge of the osteotomy needs to be positioned more toward the labial, lean a bit in that direction during this procedure. Next, switch to a yellow-coded D3.8 bone compactor. Tap it to the desired depth, and the osteotomy is complete. In areas with plentiful cortical bone, a D3 stepped drill of the desired depth can be used carefully as a last step. Do not overprepare the osteotomy. If a 4.5-mm diameter, blue-coded implant is to be used, the D3.8 bone compactor is used followed by a 4.5-mm diameter, blue-coded bone compactor, and possibly a pass with a blue-coded 4.5-mm diameter stepped drill.

More and more practitioners are using the protocol just described for routine osteotomy preparation for press-fit implants, especially in the maxilla where bone tends to be softer. It conserves bone.

Extreme Angle Between Long Axis of Osteotomy and Parallelism Requirements for an Implant Abutment Component

The condition of an extreme angle between the long axis of the osteotomy and parallelism requirements for the implant abutment component occasionally is encountered. When it is, the first step is for the laboratory to mill the 14-degree MH-6 abutment for parallelism. If the degree of

lack of parallelism is too great for this action to succeed, a custom-made abutment can be fabricated and used. In such cases, careful attention to soft-tissue contours and esthetics is required.

Minimal Interocclusal Clearance

If adjustment for proper interocclusal clearance leaves too little abutment surface for stable cementation of the final replacement tooth, switch to a screw-type abutment that will allow the replacement to be screw fastened to either the incisal or lingual, as determined by esthetic requirements. Abutments suitable for all these options are available from the manufacturer.

Inadequate Frictional Fit of Implant on Final Placement

At time of implant placement, if there is insufficient primary intention against bone, simply ramp the ridge crest about 0.5 mm, confirm adequate depth of available bone, and redrill with the final color-coded coordinated stepped drill. Hold steady while doing so. Do not let hand motion or eccentric rotation caused by a faulty handpiece or contra angle oversize the osteotomy.

VARIATIONS AND ALTERNATIVES

Submerged and Semi-Submerged Healing Options

The benefits and detriments of the submerged and semi-submerged healing protocols have been discussed throughout Chapters 10 and 11. Fully protected afunctional healing is of prime importance to achieve osseointegration, regardless of which option is used.

If the semi-submerged healing option is used, select a gingival former of the same diameter as the implant, and of collar height that will be flush with or no more than 1 mm above the gingiva during healing. Do not use a flipper as a provisional in such a case, and be sure when bonding the first provisional tooth to the adjacent teeth that the provisional restoration does not impinge on the gingival former.

Sequencing of Transfer Coping Impressions

The sequencing of transfer coping impressions is not standard throughout the profession. In the teaching case in this chapter, direct bone impressioning is performed immediately following implant insertion. This enables the laboratory to fabricate at leisure the second provisional tooth replacement over the ProTect provisional abutment during the 4 to 6 months of healing time.

The first master impression over transfer copings can be taken at the implant exposure visit following 4 to 6 months of postinsertion healing. This allows for less time to fabricate the second provisional replacement tooth, and necessitates that the original provisional prosthesis be

worn for a longer period. If the original provisional prosthesis was a crown bonded to the adjacent tooth, this bonding now needs to be redone.

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13 Plate/Blade Form Implants

Treatment of Posterior Partial Edentulism Diagnosed for a Fixed Prosthesis With Natural Co-Abutments

BENEFITS AND DESCRIPTION OF THE MODALITY AND SYSTEM USED IN THE TEACHING CASE

Plate/blade form implants are 65% narrower labio/buccolingually than conventional root form implants. Because of the various configurations that accommodate the anatomy of available bone in partially and totally edentulous ridges,¹ most cases that present for treatment are suitable candidates for mainstream plate/blade form treatment. The Oratronics Osteo-Loc Generation-Ten Plate/Blade Form System used in the teaching case in this chapter offers a broad range of implant configurations to take maximum advantage of narrow and shallow available bone. The One-Stage Oratronics Weiss Osteo-Loc Standard Plate/Blade Form Implant System has been granted full acceptance by the American Dental Association (ADA) for use with natural co-abutments.² No other implant system of any modality has been granted acceptance for treatment that includes taking advantage of the substantial additional support afforded by natural co-abutments. A more detailed analysis of the use of natural co-abutments is presented in Chapter 16.

Tissue Integration Options

For reasons best understood in terms of biomechanics and physiology, all abutments supporting a prosthesis should have an equivalent mode of tissue integration. Because the plate/blade form is the only modality proven to successfully function long-term in either the osteopreservation or osteointegration mode of tissue integration, it has broad diagnostic applicability in treatment planning.³⁻⁶ Although plate/blade forms can be joined to natural co-abutments, an advantage of the osteopreservation mode of tissue integration (Fig. 13-1), they can also osteointegrate. Osteointegrated plate/blade forms can help eliminate the need for cantilevering extensive root form-supported prostheses by adding biomechanically compatible distal support in shallow bone under sinuses and over inferior alve-

olar canals. Because of their basic shape and comparatively large width (diameter), conventional root form implants generally can only be used in the minority of healed partially edentulous ridges in the premolar and molar areas of the mandible and maxilla. Using the osteopreservation mode of tissue integration, plate/blade form implants with natural co-abutments can treat the majority of such cases. In non-mainstream, totally edentulous cases, when root forms are used to support a fixed prosthesis, distal cantilevering typically is required because of proximity to the mental foramen and insufficient depth of bone over the inferior alveolar canal or under the sinuses for further placement of root form implants. Distal cantilevering was performed in the seminal root form clinical trials most often cited in the literature.⁷ In many such cases, osteointegrated two-stage plate/blade forms can be placed into healed edentulous premolar and molar ridge areas to support what would otherwise have been cantilevered pontics (Fig. 13-2).

Non-mainstream complete-arch cases can also be fully supported by three to four plate/blade form implants, which the clinician can cause to heal in either the osteopreserved or osteointegrated mode of tissue integration (Fig. 13-3).

Preparation for Treatment

Diagnosis and treatment planning are routine. Periapical radiographs, supplemented by panoramic radiographs if desired, are all that are required. Out-of-office radiography is not required for mainstream cases.

Technique-Permissive Implant Insertion

In mainstream cases, the implant insertion protocol is organized, simple, and predictable. Local anesthetic is easy to administer. The incision is routine, and tissue reflection is minimal. Osteotomy preparation is performed quickly using only one osteotomy bur, or a maximum of two. Im-

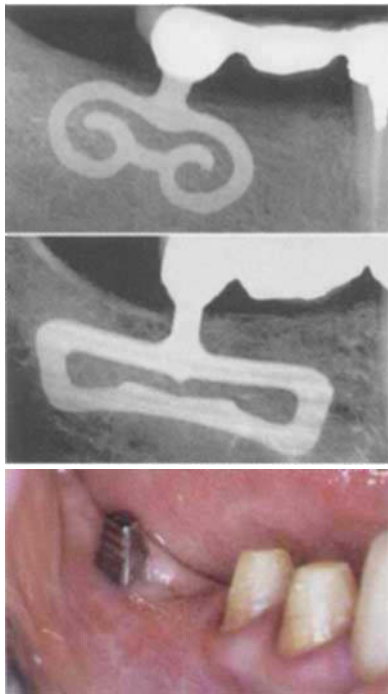


FIG. 13-1 ■ Osteopreservation—one-stage implants with natural co-abutments.

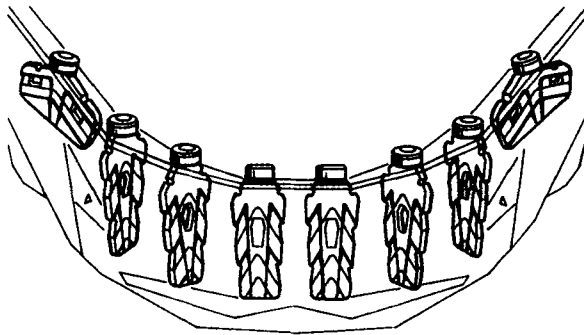


FIG. 13-2 ■ Osteointegrated plate/blade forms serving as distal abutments in thin or shallow bone.

plant insertion is aided by a well-designed set of seating instruments that are easy to use and adapted for every need that may arise during the procedure. Bone augmentation or spreading is not required in mainstream cases. Experienced practitioners often complete the insertion of a plate/blade form implant in a routine office visit of 30 to 45 minutes.

Whereas plate/blade form implant insertion is rarely difficult in mainstream cases, it can be demanding in more complex cases, in which there may be marginal available bone, severe undercuts, and/or sharp curvature of the arch. In addition, when several implants are used, they require bending for abutment parallelism among them. Bone augmentation rarely is required.



FIG. 13-3 ■ Complete arch fixed prostheses supported by osteopreserved or osteointegrated plate/blade forms.

Restorative Simplicity

Mainstream osteopreserved plate/blade form cases usually are restored with three-, four-, or five-unit fixed prostheses that are conventionally fabricated and cemented into position. The practitioner uses the same system favored when fabricating conventional fixed prostheses of similar size over natural abutments. The same master impressions, bite registrations, shade selection, trial seatings, occlusal adjustments, and the like are used. No special training is required to accomplish the prosthodontic phase of treatment. No special components need be affixed to the implant, which is supplied as a single contiguous unit with the abutment attached to the body. At the time of insertion, the abutment portion has already been adjusted for parallelism and interocclusal clearance. In addition, because most plate/blade form buccal/labial pergingival sites are in attached gingiva, the crown over the abutment may be ridge lapped if esthetic considerations indicate that doing so is desirable. The criteria and procedure for ridge lapping are covered later in this chapter. This prosthodontic simplicity affords significant advantages in terms of ease of fabrication, cleansability, reduced treatment time, and predictability.

Proven Long-Term Success/Survival Rates

The Oratronics Weiss Osteo-Loc Standard One-Stage Plate/Blade Form Implant System has been given full acceptance by the ADA. This acceptance was granted in part as a result of independent government-funded clinical trials conducted by the Veterans Administration at five hos-

pital centers,⁸ and replicated at Harvard University⁵ under grants from the National Institutes of Health. These controlled, prospective, independent, longitudinal, randomized clinical trials are recognized as being among the finest ever conducted to validate the safety and efficacy of a dental implant system.⁹ They are discussed in detail in Chapter 8.

In addition, the plate/blade form modality has been successfully used for more than 35 years in millions of cases worldwide. Their use conserves bone long-term in edentulous alveolar ridges, and helps preserve remaining natural teeth that would otherwise be clasped or used for attachment if conventional removable partial dentures were used.⁸

Unique Features

The unique features of plate/blade forms provide substantial benefits to treatment. Plate/blade forms afford the clinician the only opportunity to use a modality that can succeed in either the osseointegration or osteopreservation mode of tissue integration. The implants in the system used in the teaching case are coined, affording significant metallurgic and physiologic benefits.¹⁰ Treatment time, costs to dentist and patient, and trauma are low. Ability to cleanse the restoration and general esthetics are excellent. Prosthodontic procedures are conventional, requiring little or no special training. Only one or occasionally two burs are all that are required for osteotomy preparation. Insertion instrumentation is simple, easy to use, and inexpensive. Conventional high-speed arotors with externally cooled burs are routinely used.^{11,12}

The implant interface substantially increases surface area. It is impressed into the metal, not applied to it, thus avoiding the dissolution, cracks, and delamination sometimes associated with coatings. The implant body can be curved to follow the arch, and the abutments can be angled at chairside for parallelism. The width and variety of plate/blade form configurations allows treatment to take advantage of most healed partially or totally edentulous alveolar ridges. One plate/blade form implant used in a mainstream case can be functionally equivalent to two or three root forms.

Nomenclature and Configurations of Plate/Blade Form Implants

The mainstream application of the Oratronics Osteo-Loc Generation Ten One-Stage Plate/Blade Form Implant System is taught in this chapter (Fig. 13-4). The one-stage implant is fabricated in one solid piece, with the abutment(s) integral with the body. No components are required. Abutments are 7 to 8 mm high, tapered to promote ease of achieving parallelism, and faceted to form an unequal-sided octagon to enhance cement retention. Toward the occlusal of each abutment, four lines are spaced 1 mm apart for guidance in making adjustments for interocclusal clearance. Beneath the abutment is the **safety**

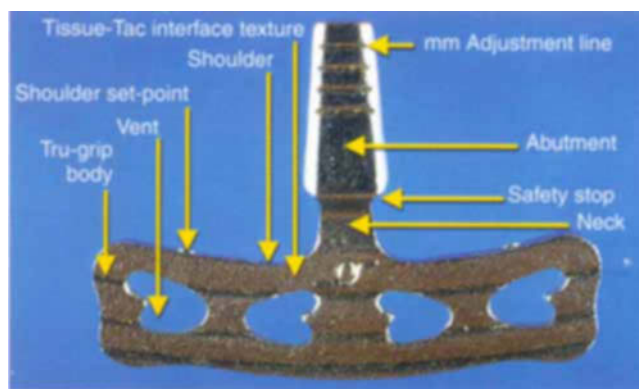


FIG. 13-4 ■ One-stage Oratronics Generation Ten plate/blade form.

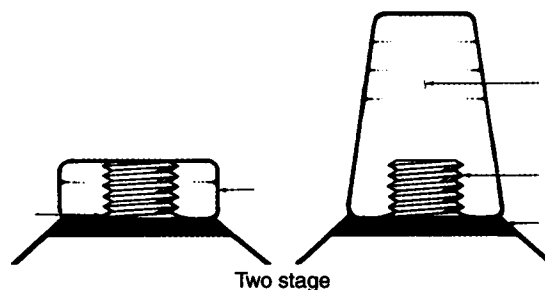


FIG. 13-5 ■ Universal healing collar (left) and abutment (right).

stop, a bevel that wedges within cortical bone at the ridge crest to enhance stability at the time of initial seating, and acts to prevent overseating of the implant as it is tapped into position. The osteotomy width at the abutment area after seating is slightly more than 1 mm, whereas the bucco/labio-lingual width of the safety stop is 3 mm. The 2 additional millimeters rest securely on solid buccal and lingual cortical bone. The two-stage configuration is the same as the one-stage, except that it has a removable universal abutment that screws down onto a 2.5-mm J-threaded post that rises from the safety stop. Each two-stage implant is supplied with a removable universal abutment and a removable healing collar (Fig. 13-5).

The neck extends from the safety stop to the shoulder of the implant, which forms the crestal border of the body. The neck ensures that the shoulder is positioned below the crest of the alveolar ridge. During the healing process, bone grows over the shoulder to encase the implant for improved retention. Near the mesial and distal ends of the implant, on the crestal surface of the shoulder, are circular indentations called **shoulder set-points**. These are used to aid in implant seating by engagement with a shoulder set-point seating instrument. Using the shoulder set-points allows one to control relative mesio-distal seating to enhance parallelism with other implants and/or natural co-abutments.

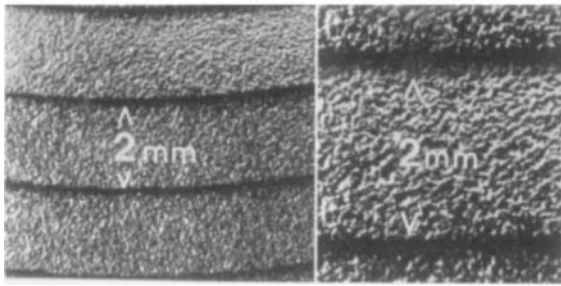


FIG. 13-6 ■ Tissue-Tac interface texture impressed into the interface.

The body of the implant is bordered by the shoulder, its mesial and distal ends, and the edge of the deepest portion, or base, of the implant. Standard implants have openings at the base, and configurations called **feet**. These openings permit additional bony ingrowth from the base crestally, as well as bucco/labio-lingually. Generation Ten implants have a closed base, with a strip called a **force distribution bar**, round in cross section, running its length to biomechanically enhance the implant's ability to diffuse and transmit functional loads. Within the body of the Generation Ten implant are vents, which permit bucco/labio-lingual bony ingrowth to enhance physiologic health and vascular communication between the buccal/labial and lingual plates of bone on either side of the implant. Viewed in cross section, the implant is tapered from shoulder to base. This taper enhances frictional fit and retention on the day of implant insertion, and reduces shear at the interface during function. Coined into the body of the implant on the buccal/labial and lingual surfaces are a series of wedge-shaped areas running linearly from mesial to distal, comprising the **Tru-Grip Body**. This unique feature increases interface area and enhances implant stabilization and resistance to dislodging forces. Also impressed into the implant interface area at the time of coining is the Tissue-Tac surface texture (Fig. 13-6). This smooth, undulating surface further increases interface area by approximately 300%. It cannot resorb, crack, or delaminate. The implant can be handled safely while making contour adjustments at the time of trial seating during insertion. If the interface brushes against soft tissue, cells do not abrade into its surface.

Incorporating Plate/Blade Form Treatment into Practice

The plate/blade form is an excellent modality to study early in one's learning curve because of its wide range of applicability, relatively small total treatment time, reduced number of treatment visits, conventional prosthodontics, reduced costs, ease of training, and use of the same high-speed drill and handpiece used in conventional dentistry.

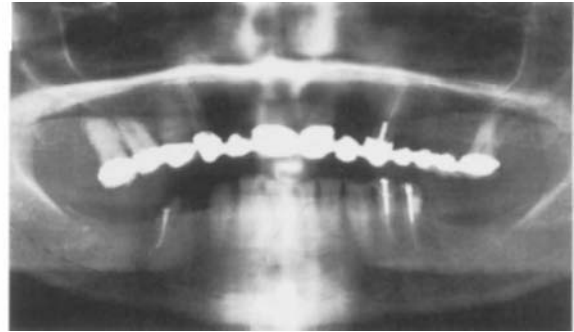


FIG. 13-7 ■ Panoramic preoperative radiograph showing bilateral posterior edentulism in mandible.

TYPICAL MAINSTREAM CASE—DIAGNOSIS, TREATMENT PLAN, AND END RESULTS

Case as Presented

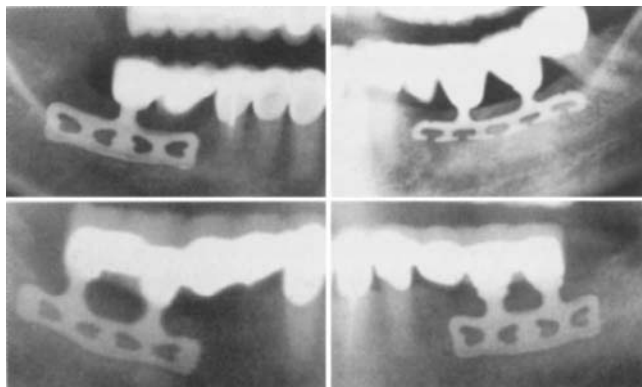
Patient's Story. A typical mainstream case presents with posterior partial edentulism in either the maxilla or mandible. The patient may have a removable bilateral free-end saddle partial denture, in which case one may hear complaints of complications associated with the natural abutments that have either been clasped or fitted with semi-precision or precision attachments, or complaints of odor, compromised function, esthetics, and gingival tissue complications. When no removable prosthesis exists, or one cannot be tolerated, added concerns are a more significant inability to function; interference with speech patterns; sunken, hollow cheeks; and loss of facial height.

Clinical Appearance. Examination reveals a loose, unesthetic denture; poor hygiene; some loss of gingival height; and perhaps the initial stages of bone loss around abutment tooth roots. Often, accelerated wear of the occlusal and incisal surfaces of the remaining teeth is observed. Facial contours may be compromised, and interocclusal clearance reduced. The edentulous portion of the alveolar ridge is full, with adequate bucco-lingual width and a good band of attached gingiva.

Radiographic Interpretation. The radiograph reveals adequate osseous support around potential natural co-abutments, and sufficient length and depth of available bone to accommodate the insertion of adequate implant abutment support to withstand anticipated functional loads long-term within physiologic limits of health. The landmarks and osseous borders are clearly identified (Fig. 13-7).

Rejected Alternative Treatment Plans

The practitioner and the patient do not feel that adjustments to an existing partial denture or the fabrication of a new one would be satisfactory. The status quo is also unacceptable, for the conditions about which the patient has complaints would remain and become exacerbated over time. Therefore, implant treatment is indicated. A subperiosteal

FIG. 13-8 ■ Completed mainstream plate/blade form cases.

BOX 13-1 ■ VISIT-BY-VISIT TREATMENT OBJECTIVES

Preoperative procedures

Visit 1: Implant insertion

Visit 2, week 1: Suture removal

Visit 3, week 2: Master impression and interarch occlusal registration

Visits 4 to 5, weeks 3 to 5: Fabrication, try-in, and adjustment of final prosthesis

Visits 6 to 7, weeks 6 to 7: Cementation of final prosthesis

implant is not indicated in this case. There is too much alveolar bone, which would continue to resorb after placement of a subperiosteal, causing substantial complications in the future. Root forms are not indicated in this case if the treatment is to remain mainstream, in part because the patient has time constraints related to the number of visits and elapsed time in treatment. Teeth adjacent to the edentulous area require restorative treatment unrelated to implant treatment, so avoiding reduction of these teeth is not a consideration. In addition, the patient is reluctant to undergo the bone augmentation that would be required to obtain sufficient bone width and depth to accommodate root form dimensions. A basic tenet of mainstream implant dentistry is to fit the implant to the patient, not the patient to the implant.

Accepted Treatment Plan—An Overview of Visit-By-Visit Case Sequencing

The objectives of each of the treatment visits for the teaching case in this chapter are shown in Box 13-1. It is important to have a basic understanding of the entire course of treatment, so that one can appreciate how the step-by-step procedures presented in this chapter contribute to ultimate success.

Completed Case

Having the goal of treatment firmly in mind during each patient visit is important. Every step in each procedure is directed toward successful completion of the case. For this

reason, the end result is presented here, to help the reader understand how each step of treatment contributes to the final objective, and to convey the satisfaction and benefits of treatment for the patient and the practitioner.

Patient's Story. The treatment goals have been achieved. The patient's missing teeth have been replaced with a nonremovable, comfortable, esthetic restoration that is efficient and easily maintained, and that does not interfere with normal control of speech. The patient is pleased and grateful.

Clinical Appearance. The esthetics of the completed prosthesis more closely resemble those of conventional three- or four-unit fixed bridges than do those of other implant modalities. This is due to ridge lapping of the crown that seats over the implant abutment, enabled by the predictable presence of attached gingiva. In nonesthetic areas posteriorly, the crown can be bullet-shaped for greater ease of cleansability, especially for elderly or infirm patients. However, ridge lapping of plate/blade form-supported crowns has been successfully accomplished for more than 30 years, and should be used to full advantage. With proper home care instruction, excellent hygiene is routinely achieved.

Radiographic Interpretation. Postoperative panoramic and periapical radiographs reveal a well-positioned implant. The landmarks and borders surrounding the seated implant have not been abridged or traumatized. The restorative prosthesis shows good marginal adaptation to the implant and natural co-abutments. A review of several postoperative radiographs reveals harmony of the axial inclination of the implants, the result of careful planning and execution of treatment (Fig. 13-8).

Microscopic Interpretation at the Interface. Following healing, light microscopy and scanning electron microscopy (SEM) reveal that the collagenous fibers of the osteostimulatory peri-implant ligament are organized in a manner similar to the fibers of the periodontal ligament. The fibers are bundled, run parallel to one another, often anastomose, and are held together to act in unison by a network of **reticular fibers**¹³ (Fig. 13-9). The collagen fibers attach to the first and often second layers of trabeculae of the cribriform plate-like dense accumulation of trabecular bone that forms the socket close to the implant (Fig. 13-10). The fibers that arise from these trabeculae pass almost vertically to the implant interface, weave around and



FIG. 13-9 ■ Scanning electron microscopy of peri-implant ligament fibers.

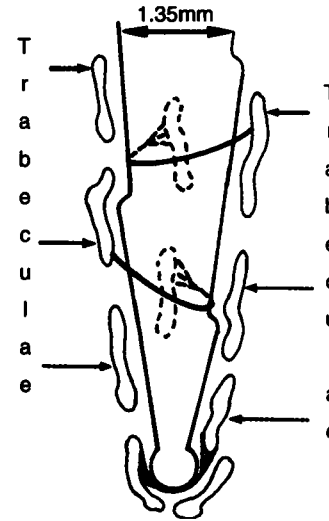


FIG. 13-11 ■ Peri-implant ligament fibers encompassing plate/blade form implant.

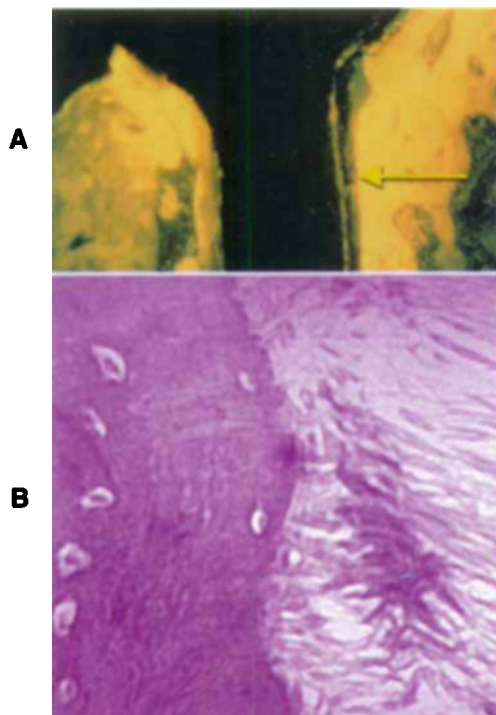


FIG. 13-10 ■ Peri-implant ligament. Tetracycline labeling (A) and conventional staining (B).

between vents and the borders of the implant body, and reinsert into other trabeculae (Fig. 13-11). Thus, they form a sling around the implant, the fibers of which are stressed in function to stimulate the trabeculae into which they are inserted at each end. This is hypothesized to produce bioelectric, cell-generated, and ground substance-generated signals that result in bone deposition on the trabecular

BOX 13-2 ■ PREOPERATIVE PROCEDURES

- Quantify available bone
- Choose mode of tissue integration
- Choose single- or double-abutment option
- Select ideal implant configurations
- Prepare and temporize natural co-abutments
- Prescribe preoperative medication

surface closest to the implant interface, known as the osteostimulatory effect.¹⁴ A detailed explanation of this hypothesis is given in Chapter 6.

PLANNING AND PROCEDURES BEFORE IMPLANT INSERTION

The steps that are performed before the implant insertion visit are shown in Box 13-2.

Osteopreserved One-Stage and Osteointegrated Two-Stage Options

In mainstream cases supported by a combination of plate/blade form implants and natural co-abutments, the one-stage osteopreservation mode of tissue integration is used. It is axiomatic that the tissue integration around all of the abutment support under a prosthesis should be biomechanically equivalent. Because the presence of the periodontal ligament makes teeth function in a way that is biomechanically similar to an osteopreserved plate/blade form, osteopreservation is required around the implant. The osteointegration option for plate/blade forms, which

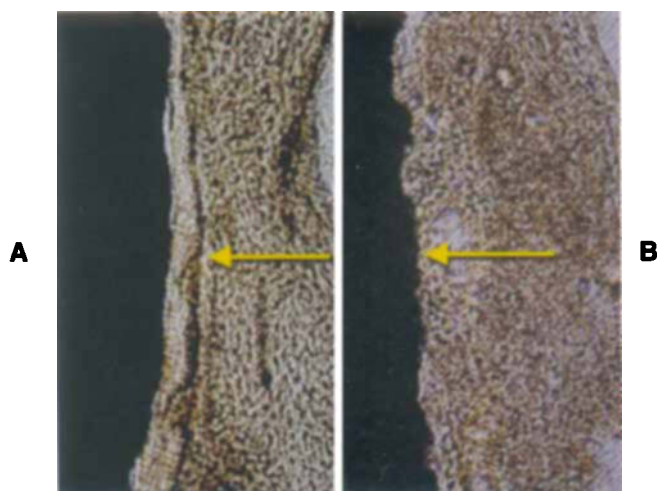


FIG. 13-12 ■ Osteopreserved (A, arrow shows peri-implant ligament) and osteointegrated (B, arrow shows bone interface) plate/blade forms.

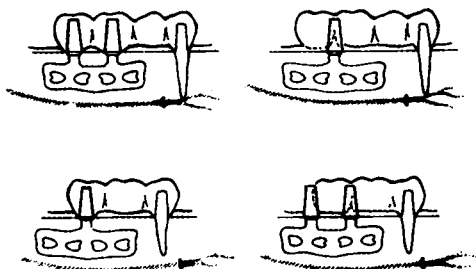


FIG. 13-13 ■ Choosing between single- or double-abutment options to avoid embrasures.

is only used when specifically indicated but nonetheless has mainstream applications, is discussed in the variations and alternatives section found later in this chapter. The type of tissue integration, osteopreservation or osteointegration (Fig. 13-12), is determined by the healing protocol chosen by the practitioner, not by the configuration of the implant.

Single- and Double-Abutment Options

An important prosthodontic consideration is correct placement of abutments under the crowns of the proposed prosthesis. Note that on the plate/blade form overlay, many implant models with the same body configuration are supplied with either one or two abutments. Abutments should pass through the pergingival site into the oral cavity in positions that allow prosthetic teeth to harmonize with the opposing dentition. When abutments are located as ideally as possible under overlying crowns, and not in embrasures, the positioning of the teeth in the proposed prosthesis is closer to ideal (Fig. 13-13). Several implant models are supplied with offset abutments. In using these implants, reverse the mesial and distal of the implant before final seating to evaluate options in abutment posi-

tioning to enhance esthetics. In closed-bite cases, in which the height of a single abutment compromises the interocclusal clearance, and reduction of this abutment for adequate interocclusal clearance would make the cementing area inadequate, a double-abutment implant doubles the cementing area to improve retention.

Select the Ideal Implant Configuration for Placement Within the Available Bone

Determine the Mode of Tissue Integration. In the teaching case in this chapter, the premolars are used as mesial co-abutments. Again, because these teeth have periodontal membranes and are not ankylosed, the plate/blade form should function in the osteopreserved mode of tissue integration. Thus, hypofunctional healing and controlled micromovement are required to provide a peri-implant ligament as the implant heals.

Determine Whether to Use a One-Stage or Two-Stage Implant. The one-stage option, used in the teaching case in this chapter, is the configuration of choice in cases that call for osteopreservation. The implant is fabricated from one piece of titanium and is fully adjustable for parallelism, interocclusal clearance, and curvature of the arch, and for increasing initial retention in the osteotomy on the day of insertion, if required.

Alternatively, the two-stage option may be used to achieve osteopreservation. Two-stage implants are provided with a threaded post extension from the neck, onto which a removable abutment or healing collar can be seated. The implant with its abutment in position is seated according to the same insertion protocol. The abutment is then removed, and the healing collar is attached. Following suturing, the healing collar remains semi-submerged, with its crestal surface flush with or approximately 1 mm above the gingival crest, resulting in the transmission of less functional load but permitting sufficient micromovement to ensure osteopreservation. Before taking the master impression for prosthesis fabrication, the healing collar is removed, and the abutment is cemented into position, adjusted, and never again removed to ensure accurate fit of the final prosthesis. Thus, only 2 weeks of reduced load is gained. This is of questionable benefit, because the load applied to a one-stage implant at this time is not excessive. During the first several weeks of healing following implant insertion, the implant is rigid. At the time of insertion it is tapped into position and wedged firmly between the buccal and lingual plates of bone, in a state of direct bone contact. The completed prosthesis is cemented over the implant and natural co-abutments. It provides rigidity for the remainder of the healing cycle and is never removed. The one-stage, one-piece implant is generally preferred in mainstream osteopreserved cases.

Quantify the Available Bone. Having determined to use an osteopreserved one-stage implant, the next step is to quantify the available bone in the area targeted for implant insertion, following the principles laid out in Chapters 3 and 9. To review briefly, use periapical radiographs to

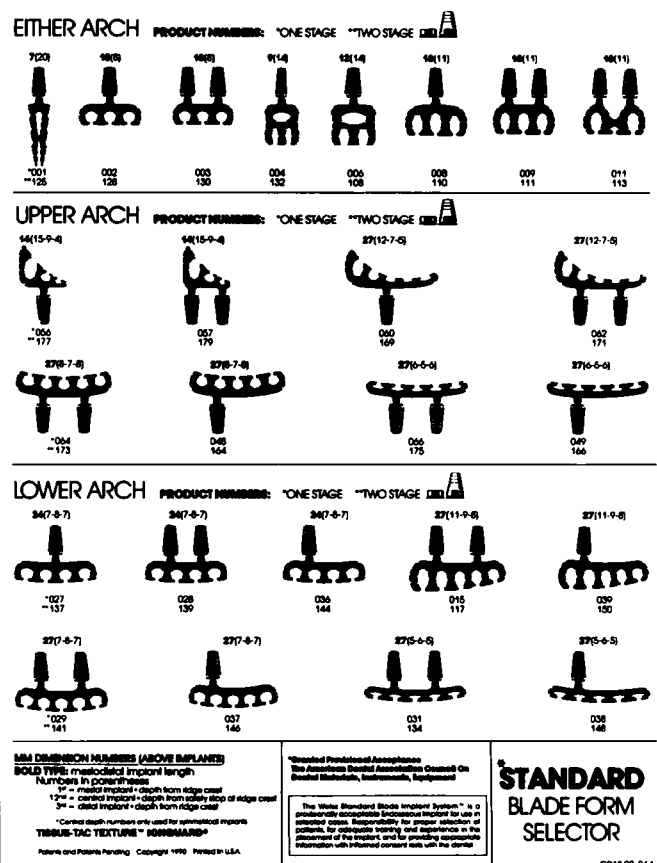
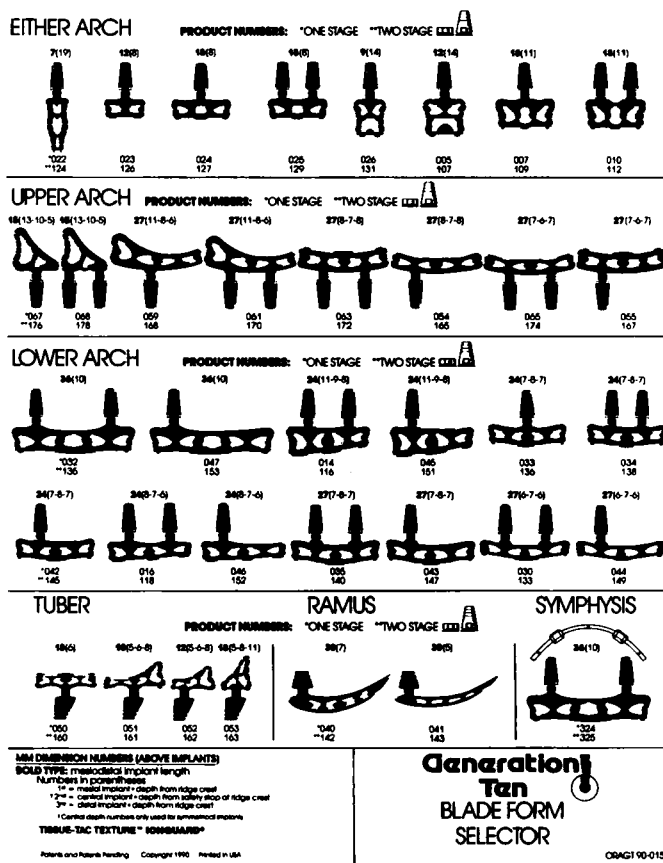


FIG. 13-14 ■ Oratronics Generation Ten (left) and Standard (right) plate/blade form overlays.

determine the length and depth of available bone between landmarks and borders. In cases of mandibular partial posterior edentulism, such as the teaching case, recall that length of available bone is measured mesio-distally from the distal of the nearest tooth root to the ascending ramus. Treatment of maxillary partial posterior edentulism, not shown in the teaching case, is also considered mainstream. In such cases, length is measured from the distal of the nearest tooth root or from the mesial border of the sinus to the distal of the tuberosity.

Outline the "usable" available bone on the radiograph to visualize the length and depth of available bone into which the implant will be inserted, according to the principles described in Chapters 3 and 9. Determine width while being mindful of the differences in gingival thickness between the mandible and maxilla. In the teaching case, placing a caliper on the gingiva 1 to 2 mm from the crest and subtracting 2 mm from this measurement accurately gives the width of the ridge in the mandible. In the maxilla, passing the caliper measuring points through anesthetized tissue until they touch bone is the most accurate method.

Select the Ideal Implant Configuration for Placement Within the Available Bone. A key question asked during diagnosis and treatment planning when one first evaluates the available bone and determines the extent of the final prosthesis bears review at this juncture. The ques-

tion is, if one inserts an implant that takes full advantage of the available bone, will it withstand the anticipated functional forces to which it will be subjected long-term within physiologic limits of health? Will support be adequate? Will the case be properly engineered? If the answer is no, reconceive the treatment plan. The possibility of over-engineering the case bears as much consideration as under-engineering. Often, so much available bone is present that use of only a portion of it is more than adequate for long-term support in health, and use of all of it would result in complications related to overengineering, potentially resulting in bone loss caused by hypofunction. In such cases, the safety margin of 1 to 2 mm clearance from landmarks and borders can often be extended to 4 to 5 mm.

The periapical radiograph marked to outline the extent of available bone is used in conjunction with a plate/blade form overlay to select the most appropriate configuration.

The plate/blade form overlay displays every configuration of implant available within the system selected—in the teaching case, the Oratronics Generation Ten system (Fig. 13-14). The overlay shows the length and depth of each implant configuration in millimeters, and model numbers for use when ordering the one-stage or two-stage options. For ease of implant selection, configurations are categorized into those for use in the upper arch, lower arch, and either arch. In general, lower arch implants are inserted into the posterior mandible, over the inferior alveolar canal. The base of

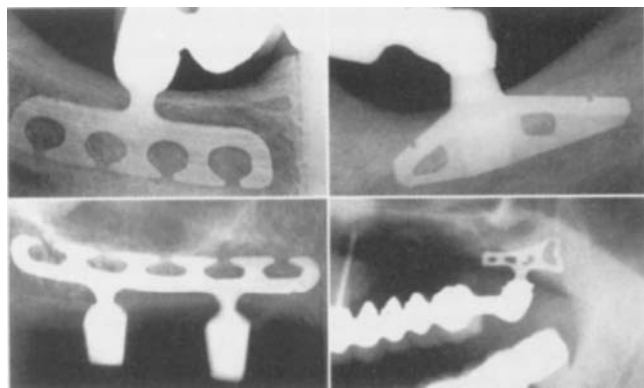


FIG. 13-15 ■ Various configurations that accommodate available bone.

each implant is curved to parallel the usual curvature of the roof of the inferior alveolar canal. In general, upper arch implants are inserted into the posterior maxilla, under, in front of, and/or behind the maxillary sinus. The curvature of each implant base reflects the curvature of the floor of the sinus. Some are for use only under the sinus, others are for use under and anterior or under and posterior to the sinus, and some are only for use in the tuberosity (Fig. 13-15).

Plate/blade form overlays come in two sizes. One, for use with periapical radiographs, has life-sized representations of each configuration. The other, for use with panoramic radiographs, has 120% representations to approximately compensate for expected enlargement of the radiograph.

In the teaching case, the target location of the implant is in the posterior mandible, and a one-stage single-abutment Oratronics Generation Ten implant is desired. Therefore, attention is directed to the lower arch or either arch implants on the Generation Ten blade form overlay. Thirteen lower arch implants are available, and six of them are single-abutment models. Above each implant on the overlay is a series of numbers. The first one, in bold type, is the mesio-distal length of the implant in millimeters. The numbers in the parentheses represent the depth of the implant measured in millimeters from the level of the safety stop down to the implant base. Some implants (e.g., models 014 and 045) are deeper mesially and shallower distally. For these implants, for example, the depth measurements are shown as (11-9-8), in which 11 mm is the depth measurement mesially from the level of the safety stop to the base, 9 mm is the depth measurement at the center of the implant, and 8 mm is the depth measurement at the distal. Note that the bodies of these two models are identical, but model 014 has an offset single abutment and model 045 has two abutments. In the case of models 033 and 034, the same choices exist, but the body of each implant is symmetrical at 24 (7-8-7), and in the single abutment version the abutment is centered. Model 042 has the same implant body, with the single abutment offset.

Place the plate/blade form overlay over the periapical radiograph such that an implant body is centered over the

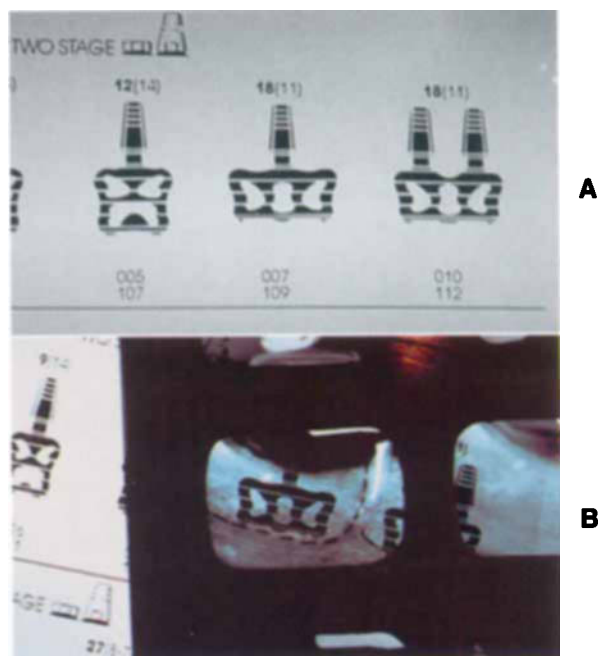


FIG. 13-16 ■ Implant overlay (A) placed over periapical radiograph indicates that base of implant is too close to canal (B).

area of usable available bone outlined earlier. Suppose one first tries model 033, but determines that the 24-mm length is too short. One would then try model 043, with a 27-mm length and one offset abutment. When the dimensions of the body are appropriate, one must determine where the abutment should be. Suppose that for prosthodontic purposes, the abutment should be toward the distal. If so, the overlay is turned over to view the abutment in its distal position. Note that in every case, once the implant body fits the available bone, it is always positioned in the same location, and only the mesio-distal location of the abutment that most nearly satisfies prosthodontic requirements is considered. In the teaching case, we try model 007, and find that its length is acceptable at 18 mm, but that its 11-mm depth is excessive (Fig. 13-16). Model 024, at the same 18-mm length, may be safer at 8 mm in depth (Fig. 13-17). Pass each implant candidate over the marked radiograph, and the optimal choice becomes evident.

Choose Backup Configurations. Having sterilized backup implants at hand is an advantage. During implant insertion, one may realize that a longer or shorter implant, a deeper or shallower implant, or a double-abutment or single-abutment implant may be more appropriate for the case at hand (Fig. 13-18).

Order the Implants and Record the Product Number and Manufacturer's Control and Lot Numbers on the Patient Record. When the final and backup configurations have been selected, order the implants. When they arrive, record each product number in the patient record in case a reorder is indicated, along with the lot and control numbers of each implant. These numbers comply with government regulations for traceability and quality control of implanted devices.

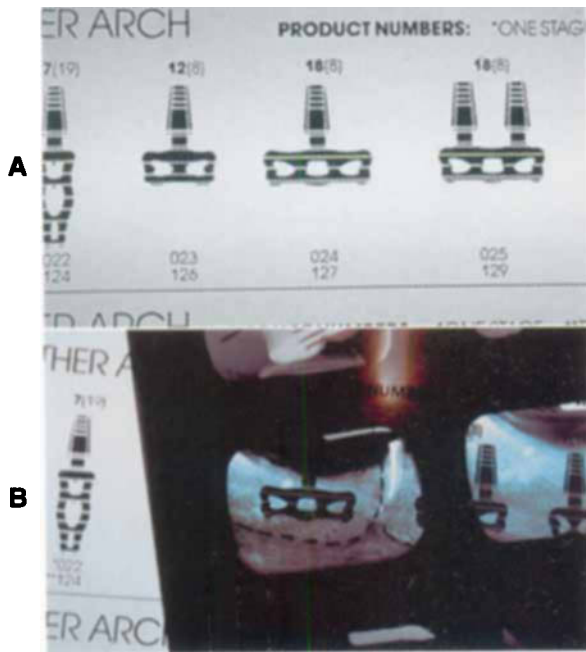


FIG. 13-17 ■ Implant overlay (A) placed over periapical radiograph indicates adequate clearance around implant (B).

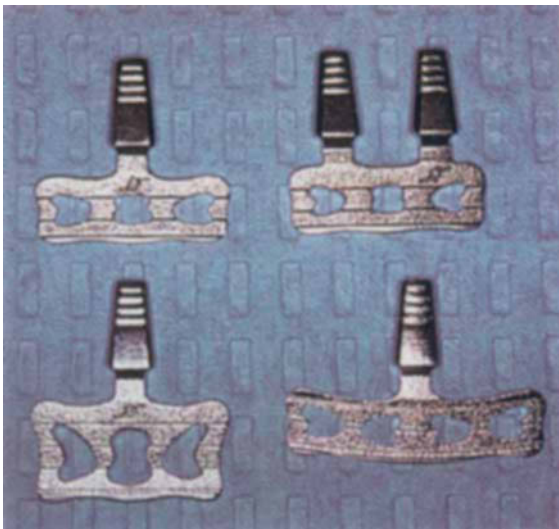


FIG. 13-18 ■ A selection of backup implants.

Adjust Implant to Clear Anatomic Landmarks

Because of the variety of plate/blade form implant configurations available, it seldom is necessary to adjust an implant to ensure clearance from a landmark or boundary. However, if the best available configuration may impinge on a landmark, the implant can be modified. Such adjustments can be made easily.

The first step is to hold the implant over the periapical radiograph marked to show the usable available bone. Note the portion of the body of the implant that extends beyond the boundary, and remove it (Fig. 13-19). A carborundum disk, green stone, or heatless wheel is used for trimming. A metal bur is contraindicated when adjusting

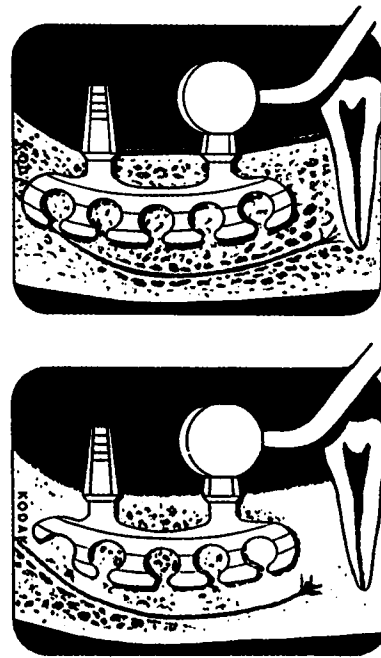


FIG. 13-19 ■ Adjusting an implant to clear a landmark.

the body of the implant to preclude contamination by metal transfer. The procedure is completed by smoothing rough edges with a sterile rubber wheel, followed by thorough cleansing and resterilization.

Adjust Abutment for Interocclusal Clearance

Basic abutment adjustments for interocclusal clearance are made before the insertion visit. Experience has shown that clearance of 2 mm or more is ideal, and that 1 mm is acceptable. In the mandible, the gingiva is most often 1 to 2 mm thick, and in the maxilla gingival thickness can be as high as 10 mm. Implant abutments are 7 or 8 mm in height as measured from the safety stop. To test whether adjustment is required, and if so to what extent, observe on the study models or intraorally the distance from the gingival crest to the occlusal surface on the opposite arch. If this distance is 7 mm or greater, no adjustment is required, because the implant safety stop at the base of the abutment will be 2 mm apical to the gingival crest when seated. If the distance is less than 7 mm, the abutment is reduced in height by a minimum of the number of millimeters required to make the height equal to the measured distance from the gingival crest to the opposite occlusal surface (Fig. 13-20). In measuring, always account for gingival thickness. Abutment height is reduced using a carborundum disk or heatless wheel, followed by smoothing of rough edges.

Implant Sterilization

Implants are supplied sealed in two pouches. The outer pouch contains product and usage information required by

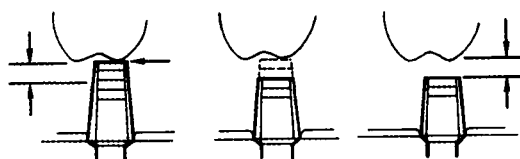


FIG. 13-20 ■ Adjusting an abutment for interocclusal clearance.

Food and Drug Administration (FDA) regulations and the Good Manufacturing Practices Act. The inner pouch contains the implant. If no adjustments to the implant body or abutments are required, do not remove the implant from the inner pouch. If adjustments are required, remove the implant, make necessary adjustments using only solid titanium or titanium-tipped instruments, and repouch the implant as one would for the routine sterilization of dental instruments. Sterilize the implant in the conventional manner. Guidelines for gravity air displacement steam sterilization are for an exposure time of 30 minutes at 250° F (121° C) or 15 minutes at 270° F (132° C). For prevacuum steam sterilization, an exposure time of 4 minutes is required at 270° F (132° C). The sterilized implant in its pouch is transferred to the implant insertion surgical tray setup. The implants used in the teaching case can be cleansed and resterilized, even if they are tried into an osteotomy and a decision is made to use a different configuration.

Prepare and Temporize Premolar Abutment(s)

For **solo practitioners** who will both insert the implant and fabricate the final prosthesis, preparing and temporizing the natural co-abutments is almost always accomplished during the implant insertion visit, under the same local anesthetic. For the first several mainstream cases being treated, it may be advisable to prepare (Fig. 13-21) and temporize the natural co-abutments before the implant insertion visit, at least until the insertion procedure becomes routine. It is also advisable to prepare and temporize the natural co-abutments before referring a patient to another practitioner for implant insertion, if the team approach is used. In such cases, the insertion practitioner removes the provisional restoration on the natural co-abutments to accurately assess the parallelism requirements, and for enhanced access to and visibility of the field of operation.

Natural co-abutment preparation and temporization is performed in the same manner as for conventional fixed bridgework. Any one of several common methods, well executed, accomplishes the task.

Prescribe Preoperative Medication for the Insertion Visit

Prescribe preoperative medication for the insertion visit as discussed in Chapter 9. Recall that preoperative administration of anti-edema medication is generally not required for mainstream cases, unless the patient's history suggests that edema may be greater than normal. Nor is preopera-



FIG. 13-21 ■ Natural co-abutments prepared before implant insertion.

tive sedation recommended. Patients who take prophylactic aspirin daily are advised to discontinue doing so for at least 3 weeks preoperatively, to allow for normal clotting at the insertion visit.

VISIT 1: IMPLANT INSERTION AND PROVISIONAL PROSTHODONTICS

The steps that are performed during the implant insertion visit are shown in Box 13-3.

Confirm That Preoperative Medication Has Been Taken

As discussed in Chapter 9, it is not necessary to postpone the case if the patient has not taken the preoperative prophylactic antibiotic medication. The practitioner should have antibiotics on hand for preoperative administration in such cases. If a patient on an aspirin regimen has not discontinued its use, insertion may nonetheless be performed, with delayed clotting expected.

■ Instrumentation Setup— The Armamentarium

Two sterile tray setups are recommended. The first, which holds all instruments that do not come in direct contact with the implant during the insertion procedure, is described in Chapter 9. The second surgical tray holds all instruments involved with implant insertion, as well as the implants themselves and implant components if a two-stage implant is being used. The trays are placed side by side.

The second tray includes a semi-lunar tissue punch, channel curette and depth gauge, implant carrier, single-abutment seating instrument, double-abutment seating

BOX 13-3 ■ VISIT 1: IMPLANT INSERTION

Confirm use of prophylactic antibiotic
 Set up instrumentation
 Administer anesthetic
 Make incision
 Reflect tissue
 Mark location and extent of osteotomy
 Prepare osteotomy
 Evaluate osteotomy suitability
 Adjust implant to conform to crestal curvature, clear anatomic landmarks, accommodate interocclusal clearance, and achieve prosthodontic parallelism as required
 Perform final seating of implant
 Perform soft-tissue treatment
 Suture
 Check temporization of premolar co-abutments
 Select shade
 Provide home care instruction
 Schedule follow-up visit

instrument, shoulder set-point seating instrument, set of two bending pliers, implant remover (reverse mallet), and tissue marker. These instruments are either solid titanium or titanium tipped, and are anodized blue for ease of identification and segregation (Fig. 13-22).

Sterilization is performed as with all dental treatment instrumentation.

Presurgical Treatment

Prepare the surgical field, administer local anesthetic containing vasoconstrictor to promote comfort and control bleeding, and prepare the oral cavity and targeted tissues according to the principles and procedures described in Chapter 9.

Make Incision

Evaluate the attached gingiva, plan the incision line, incise, and ensure hemostasis according to the principles and procedures described in Chapter 9. Healed one-stage plate/blade form implant abutments have the highest percentage of attached gingiva at every aspect of the pergingival site because they are sutured within attached gingiva. The practitioner controls this. When planning the incision line, reconfirm the correct choice of implant and visualize its planned mesio-distal location by holding it above the ridge crest at its planned position. Mark the points of the mesial and distal extent of the implant on the ridge crest. Place additional marks 3 to 5 mm distal to the distal mark and 3 to 5 mm mesial to the mesial mark. Connect the most distal to the most mesial mark, on or slightly buccal to the ridge crest, with the tissue marker. If the mesial extent of the marked incision line is within 5 mm of the gingival cuff of a natural tooth, draw the line through the cuff.

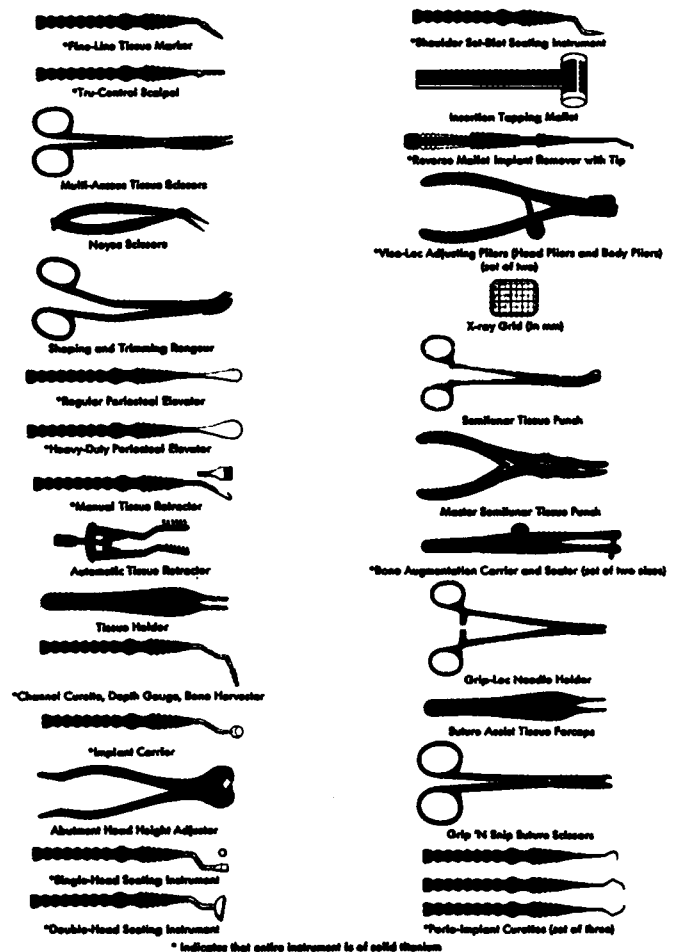


FIG. 13-22 ■ Selection of specialized instruments for implant insertion.

Reflect and Prepare Tissue Before Insertion

Reflect the tissue using the periosteal elevator, trim the tissue flap edges to ensure healing by primary intention, and cleanse and alter the exposed alveolar ridge as required according to the procedures and principles described in Chapter 9.

Mark Location and Extent of the Implant Osteotomy

Place the implant firmly in an implant carrier, with the manufacturer's logo or other identifying mark on the implant oriented toward the buccal or lingual aspect of the ridge (Fig. 13-23).

Remember and repeat this orientation to ensure ease of implant insertion at the time of trial seatings and adjustments.

Retract the flaps and hold the implant directly over the area of the ridge crest planned for the osteotomy. Using an XL channeling bur, mark the mesial and distal extents of the implant on the ridge.

A



B

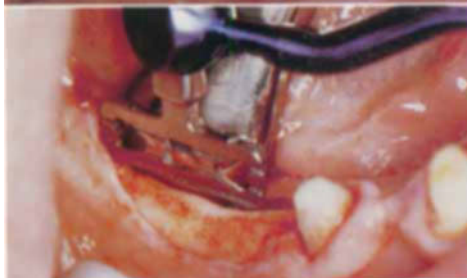


FIG. 13-23 ■ Exposed ridge (A), and use of implant carrier to confirm required osteotomy length (B).

A



B

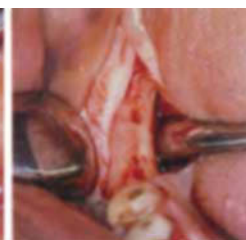


FIG. 13-24 ■ Exposed ridge (A), and bur penetrations marking mesial and distal extent of planned osteotomy (B).

The marked extent of the planned osteotomy delineates its mesio-distal positioning. This should correspond to the position of the implant when its life-sized replica on the plate/blade form overlay was held against the periapical radiograph of this area during implant selection.

With the XL channeling bur, create a 1-mm penetration 1 to 2 mm distal to the distal mark, and another penetration 1 to 2 mm mesial to the mesial mark (Fig. 13-24).

Osteotomies are prepared 1 to 2 mm longer at each end than the space to be occupied by the implant. This affords ease of implant insertion and the ability to more precisely adjust for correct mesio-distal location of the abutments.

Prepare Implant Osteotomy

Primary Penetration Through Cortical Bone. Insert the XL channeling bur into a high-speed contra angle. Orient the long axis of the bur to bisect the buccal and lingual cortical plates of bone (Fig. 13-25).



FIG. 13-25 ■ Osteotomy bone bur at correct axial inclination.



FIG. 13-26 ■ Primary ridge crest penetrations.

This bucco-lingual long-axis orientation is maintained throughout osteotomy preparation, ensuring that the maximum bone possible exists on each side of the seated implant. Parallelism with other natural or implant co-abutments is not a consideration when preparing the osteotomy. In most cases, the abutments initially are parallel with other abutments. If necessary, they are adjusted for parallelism in a subsequent step.

Using copious coolant, maintain the bur orientation, and start from the distal to prepare a series of initial penetrations 3 to 5 mm apart along the crest of the ridge (Fig. 13-26). Penetrate just through the cortical bone into the cancellous bone, to mark the path of the osteotomy. Stay on the ridge crest, whether it is straight or curved mesio-distally.

The XL channeling bur prepares an osteotomy that is slightly narrower than the bucco-lingual width of the implant. This ensures frictional fit and implant immobilization following final seating and during the early healing period. The ability to follow the mesio-distal curve of the arch is an advantage of the plate/blade form modality. The practitioner always is able to take advantage of favorable bone. No other considerations interfere, and no trade-offs occur that may compromise the use of the best available bone for prosthodontic requirements. In plate/blade form treatment, prosthodontic requirements always can be satisfied.

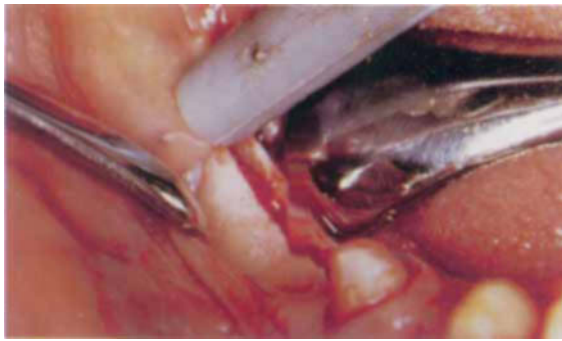


FIG. 13-27 ■ Preliminary osteotomy at 50% of planned depth.

Secondary Penetration to 50% Depth. Maintaining the bur orientation, perform the secondary penetration with adequate coolant. Starting from the distal, reenter each primary penetration and carry it to a depth equal to 50% of the depth of the implant.

Implant depth is measured from the safety stop under the abutment to the base of the implant. Glancing from the tip of the bur up the shank, note the spot that corresponds to 50% of the implant depth. With each secondary penetration, the bur is removed when that spot reaches the crest of the ridge, thus affording depth control by the practitioner. The XL channeling bur passes into cancellous bone with ease. The contra angle may be fitted to supply saline. Superior efficiency of cutting at high speed, together with the application of controlled intermittent pressure and copious external coolant, maintains a cool, cleansed field of operation. Note that the XL and XXL channeling burs are tapered to create an osteotomy that corresponds to the taper of the plate/blade form implant to be inserted.

Maintaining the bur orientation, starting from the distal, reenter the most distal penetration and carry it mesially, connecting one penetration point at a time. Repeat until the entire length of the planned osteotomy has been prepared to 50% of its final depth (Fig. 13-27).

This partial-depth intermediate osteotomy preparation is recommended for implants that are 10 mm in depth or deeper. It affords continuing control and an opportunity to change to the XXL channeling bur to complete the procedure. For implants shallower than 10 mm, the secondary penetration can be made to final depth and the osteotomy completed in one pass.

Check Location Accuracy/Bone Harvesting. The intermediate osteotomy now is cleansed and checked for dimensional accuracy with the solid titanium channel curette and depth gauge. Gently insert this instrument distally to the base of the preliminary osteotomy, and carry it mesially as it cures out and harvests a paste of bone chips and blood. If desired, this may be preserved in a sterile dappen dish on the tray setup. Several passes may be needed to clear the channel. Check the depth and evenness

of the base of the preliminary osteotomy, and make any necessary corrections to ensure conformity. Place the implant in its preliminary osteotomy to confirm that the mesio-distal length of the osteotomy can accommodate the length of the implant, with an extra 1 to 2 mm of clearance at each end.

The solid titanium channel curette and depth gauge is narrower bucco-lingually than the preliminary osteotomy, to prevent injury to its lateral walls during curettage. The instrument has the same horizontal Tru-Grip markings, 2 mm apart, that are on the surface of the implant. As the instrument is passed along the base of the preliminary osteotomy, direct depth readings can be made at every point mesio-distally along the site. Corrections are made if and as required to bring the intermediate osteotomy to its proper depth at every point.

Preparation to Final Depth. Insert the XXL channeling bur into the contra angle. Hold the tip of the bur opposite, but not against, the safety stop under the abutment. Note the point on the shank of the bur that corresponds to the base of the implant. Add 1 mm, and mark that point on the shank by spinning it against a disk. Some bone burs are premarked for depth.

This step marks the point on the bur's shank that must be brought flush with the crest of bone to ensure the proper depth of final osteotomy preparation. This will safely and predictably avoid landmarks. In rare cases in which an implant was recontoured to avoid a landmark, or if the selected implant model is asymmetrical, mark the bone bur to reflect the deepest and shallowest planned osteotomy depths.

Prepare the osteotomy to its final depth. Maintaining the bur orientation, make a series of 1-mm vertical penetrations 3 to 5 mm apart into the floor of the intermediate osteotomy, starting from the distal and proceeding to the mesial end. Reenter and complete each penetration to the final osteotomy depth as marked on the shank of the XXL bur. Reinsert the bur distally and connect each penetration until the entire length of the osteotomy has been prepared to its final depth, or to graduated depths along the length of the osteotomy in the case of asymmetrical implants.

Essentially, this technique repeats the process of creating the preliminary and intermediate osteotomies. The cutting edges of the XXL bur are 5 mm deep. At this point, they are within cancellous bone at all times, well below the cortical plate at the ridge crest. This protects the integrity of the osteotomy borders along the ridge crest as the deeper portions of the osteotomy are prepared.

Confirm Osteotomy Correctness. Confirm the proper depth of the osteotomy at every point. Hold the channel curette and depth gauge opposite the implant such that the tip of the depth gauge is at the base of the

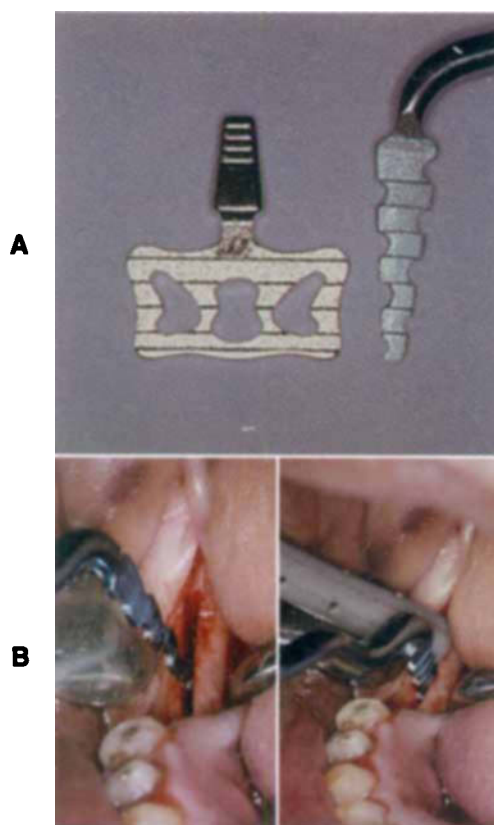


FIG. 13-28 ■ Depth gauge (A) used to measure depth of osteotomy (B).

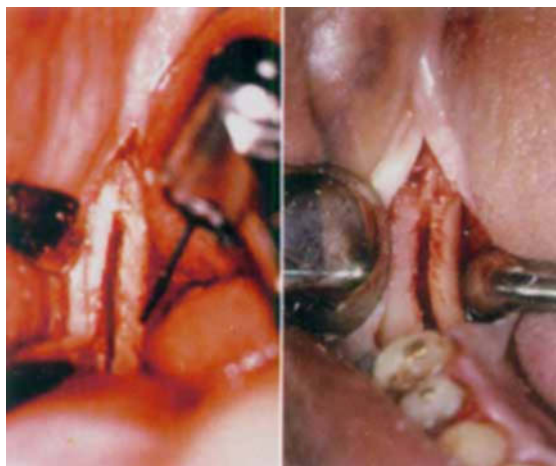


FIG. 13-29 ■ Completed osteotomies.

implant. Note the point on the depth gauge that corresponds to the level of the safety stop, and add 1 mm (Fig. 13-28). Insert the instrument and pass it along the base of the osteotomy from distal to mesial, and observe the relationship of the noted point to the ridge crest at all times. Harvest bone chips in the dappen dish, if desired. If the depth gauge reveals that a portion of the osteotomy is too shallow or uneven, deepen or even it. Remeasure to confirm the correction. Osteotomy preparation now is complete (Fig. 13-29).

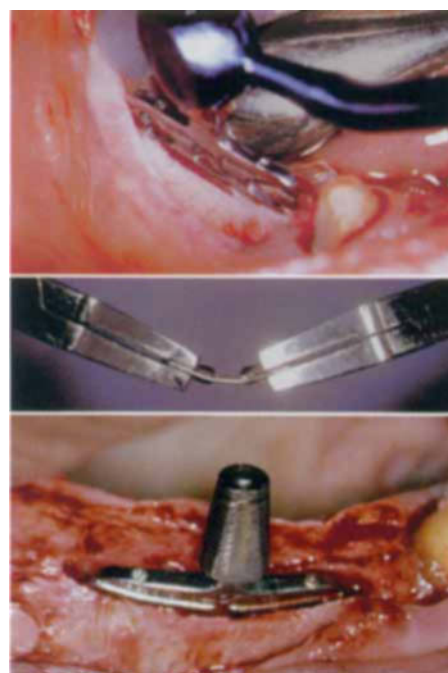


FIG. 13-30 ■ Curving of implant to conform to ridge crest.

In the mandible it is important to avoid the roof of the inferior alveolar canal and the mental foramen. The implant should be placed at least 1 to 2 mm distal to the foramen and superior to the roof of the canal. In the maxilla, the implant should be placed not closer than 1 mm to the floor of the maxillary sinus. Proper selection of the configuration using the plate/blade form overlay on a periapical radiograph helps ensure that these requirements can be met.

Adjust Implant Body to Conform to Mesio-Distal Ridge Crest Curvature

It may be necessary to curve the implant mesio-distally to follow the contour of the bone. To place the osteotomy within ideal bone, the mesio-distal curvature of the bone is followed during osteotomy preparation. All bending adjustments are performed with the titanium-tipped bending pliers. Using the manufacturer's logo or other identifying mark on the implant as a positioning guide, note which side is buccal and which lingual for orientation during bending. One of the pliers is held parallel to the implant shoulder from the distal, and the other from the mesial. View the implant base from below, and bend the implant such that it matches the curve of the arch as closely as possible. Hold the implant above the crestal opening of the osteotomy, observing the logo or other identifying mark to orient it properly bucco-lingually, and check both the shoulder and inferior borders of the implant to determine whether the adjustments are adequate. Correct if necessary (Fig. 13-30).

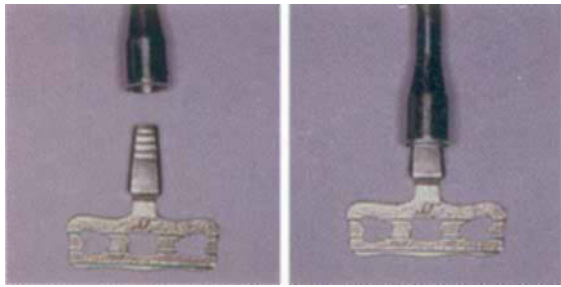


FIG. 13-31 ■ Positioning of seating instrument for malleting.

Because the dental arches are curved, osteotomies often are curved. Previous periodontal conditions and prior surgical interventions may cause uneven ridge healing. These result in osteotomies that reflect this varying anatomy as the buccal and lingual cortical plates are bisected during osteotomy preparation. Note that adjusting the implant to conform to the patient's anatomy is only possible using plate/blade form implants. This unique adaptability is one of their more important attributes. It enables the use of optimum areas of available bone.

Adjust Implant to Clear Anatomic Landmarks

Preliminary adjustments to the body to clear anatomic landmarks were made before the insertion visit as previously described, if required. Again, hold the implant opposite the periapical radiograph, and reconfirm that any adjustments that have been made are adequate. If not, further alter the implant contours as required.

Checking adjustments ensures the precision of the implant placement procedure. Safety is the most important consideration at each step.

Partial Implant Seating to Test Need for Further Adjustments

Test Mesio-Distal Curvature. Place the implant to a depth of 2 to 3 mm within the osteotomy. If the implant body adjustments to conform to mesio-distal crest curvature need to be perfected, remove the implant and do so now.

Recall that the osteotomy, viewed bucco-lingually, is tapered to correspond to the implant taper. Providing that the implant curvature has been adjusted to approximate the osteotomy curvature, the implant can easily seat to the 2- to 3-mm depth, or slightly deeper. The implant seating instruments may be used.

Test Abutment Location for Prosthodontic Ease. Consider the mesio-distal position of the abut-



FIG. 13-32 ■ Partially seated implants with safety stops 2 mm above ridge crest.

ment(s) for prosthodontic ease. Recall that the osteotomy was prepared a few millimeters longer than necessary at each end. The implant may now be repositioned more mesially or distally if advisable for ideal abutment positioning.

Although it is helpful to position the abutments under the crowns of the planned prosthesis, it is not essential to do so. This is one of the benefits of the prosthodontic versatility of the plate/blade form implant.

Technique Options for Partial Seating/the Progress Radiograph. Place a seating instrument over the abutment(s) of the implant. In the mandible, use hand support under the inferior border. In the maxilla, place the patient's head securely against the headrest. With the tapping mallet, gently tap the seating instrument until the safety stop under each abutments is 2 mm from the ridge crest (Figs. 13-31 and 13-32).

Hold the long axis of the seating instrument parallel to the long axis of the osteotomy, and thus parallel to the long axis of the body of the implant, as it is gently tapped into position. A tapping mallet is required to overcome friction between the implant interface and bone as it seats deeper into the osteotomy, which was prepared narrower bucco-lingually than the width of the implant. All seating instruments are offset to promote easy access, lip clearance, and visibility.

In the mandible, single- or double-abutment and shoulder set-point seating instruments usually are used. Tap the mesial and then the distal, working the implant to its desired depth with the safety stop 2 mm from the ridge crest. For a single-abutment implant, use the shoulder set-point seating instrument to engage first the mesial and then the distal shoulder set-point in the implant shoulder. For a double-abutment implant, the single-abutment seating instrument can be used over the mesial and then distal abutment alternately to accomplish the same result, and the shoulder-set points can also be used. When the implant is partially seated, take a periapical progress radiograph.

FIG. 13-33 ■ Use of reverse mallet implant remover.

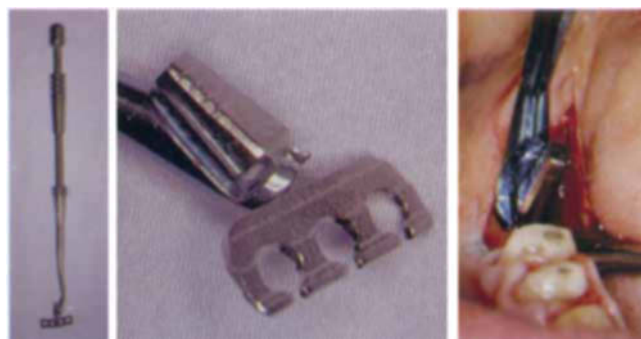


FIG. 13-34 ■ Position of beaks of adjusting pliers to bend across implant neck.



Preliminary seating now is completed. The periapical progress radiograph is examined to reconfirm appropriate configuration selection. Check that sufficient available bone is present such that after final seating of the implant an additional 2 mm into the osteotomy, at least 1 mm of clearance from the nearest landmarks remains. Also confirm that recontouring to avoid landmarks, if performed, is adequate. If not, correct this adjustment now. If the radiograph reveals much unused available bone, the implant originally selected may be replaced with a larger model. However, if the implant is adequate to withstand anticipated function despite the presence of more available bone, no change is required. If the progress radiograph reveals that too little available bone remains and body recontouring cannot solve the problem, a smaller backup configuration should be used.

Adjust Implant Abutment for Prosthodontic Parallelism

Check for Parallelism. With the implant preliminarily seated, check whether the implant abutment is parallel to the long axis of the crowns of the prepared natural co-abutments. If not, adjustments for parallelism are required.

Plate/blade form implants are unique in that they can predictably, routinely, and quickly be adjusted at the time of insertion to achieve parallelism for support of a fixed restorative prosthesis.

Examine intraorally to determine the angle of bend, if any, required to achieve parallelism with the other abutments. Remove the implant by engaging a titanium-tipped implant remover (reverse mallet) under the base of the safety stop, and tap the implant out of the osteotomy in the long axis of the implant body (Fig. 13-33).

Do not luxate bucco-lingually and thereby widen the osteotomy. Cleanse the implant, and orient it into its proper position by observing the manufacturer's logo or other identifying mark. A pair of titanium-tipped bending pliers are used for paralleling adjustments.

Correct Bucco-Lingual Parallelism. Position one of the bending pliers over the implant abutment with the beak even with and parallel to the safety stop. Position the second bending pliers over the implant body with the beak even with and parallel to the implant shoulder under the safety stop. Grasp the implant firmly (Fig. 13-34).

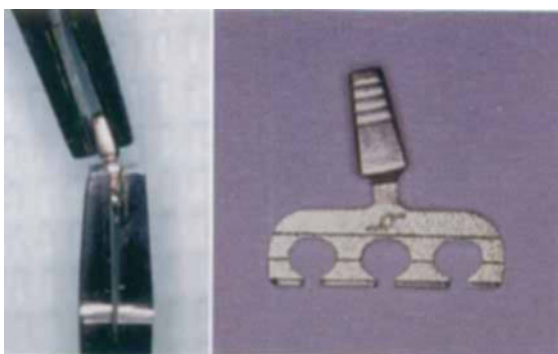


FIG. 13-35 ■ Bending for parallelism.

The exposed portion of the implant, the neck, is an area of special metallurgic grain structure across which the bending adjustments are made.

Observe the logo or other identifying mark to reconfirm the bucco-lingual orientation of the implant. View the implant in mesial profile as it is bent. Bend the abutment to the estimated angle to achieve parallelism. Reseat the implant within the osteotomy to its preliminary position, with the safety stop 2 mm from the ridge crest. Recheck for parallelism, and repeat the procedure if necessary until the result is acceptable (Fig. 13-35).

Viewing the implant's mesial profile during bending for parallelism affords the greatest control. The abutment may also be rotated slightly for better positioning. By grasping the implant to expose the neck, it may also be bent mesio-distally to improve parallelism in that plane, as shown in Fig. 13-35. The taper of the abutment in all planes promotes parallelism, and maximizes cementation retentiveness. In the maxilla, achieving parallelism is more of a challenge because of significant resorption of the buccal plate at the ridge crest. Because of this resorption, the long axis of the residual ridge is at a more acute angle to the required long axis of the implant abutment for parallelism. As a result, maxillary abutments protrude toward the buccal at a greater angle, and require lingual bending of 15 to 20 degrees, and sometimes up to 45 degrees. Although it is possible to adjust further for parallelism by selective grinding of the abutment under coolant following suturing, it is better to establish parallelism carefully via abutment bending before final implant seating.

Adjust Implant Abutment for Interocclusal Clearance

With the implant preliminarily seated, the abutment(s) parallel, and the safety stop 2 mm from the ridge crest, have the patient close into centric occlusion if opposing teeth are present. Reconfirm the adequacy of preliminary adjustments, if any, for interocclusal clearance. Make further adjustments, if required.

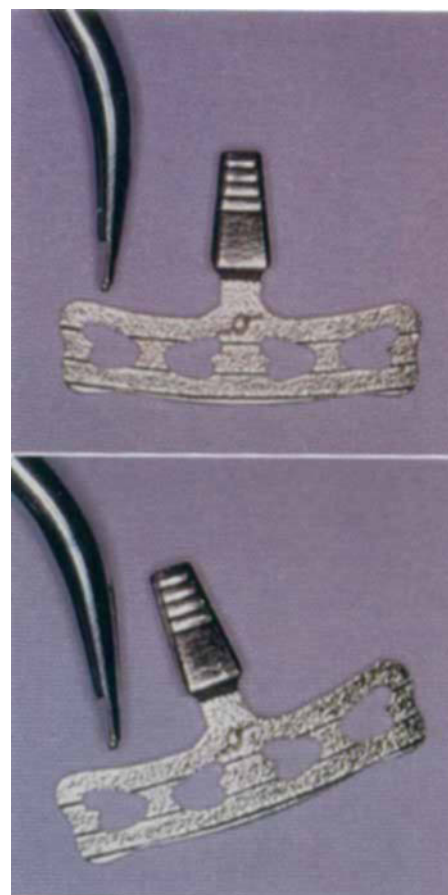


FIG. 13-36 ■ Placement of shoulder set-point seating instrument tip into shoulder set-point on shoulder of implant.

If the patient can close into centric occlusion at this time without touching the abutment, ultimately at least 2 mm of interocclusal clearance will be available following final seating, when the safety stop rests on the ridge crest. If the abutment interferes with closure before final seating, remove the implant and reduce the abutment to ensure adequate clearance. Sterile heatless wheels, green stones, and polishing wheels accomplish this task. Cleanse the implant.

Final Seating of the Implant

Technique. Final seating of the implant is performed using a titanium-tipped shoulder set-point or single- or double-abutment seating instrument, depending on the implant configuration and degree of prior abutment bending for parallelism (Figs. 13-36 through 13-38).

If the abutment is bent more than 15 degrees, making the long axes of the abutment and implant body substantially different, only a shoulder set-point seating instrument is used. All seating forces must be directed in the long axis of the implant body every time the tapping mallet strikes the seating instrument.



FIG. 13-37 ■ Use of shoulder set-point instrument.

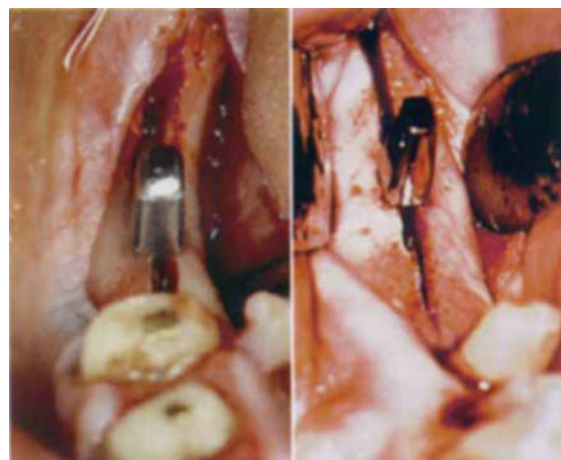


FIG. 13-38 ■ Use of single-abutment seating instrument.

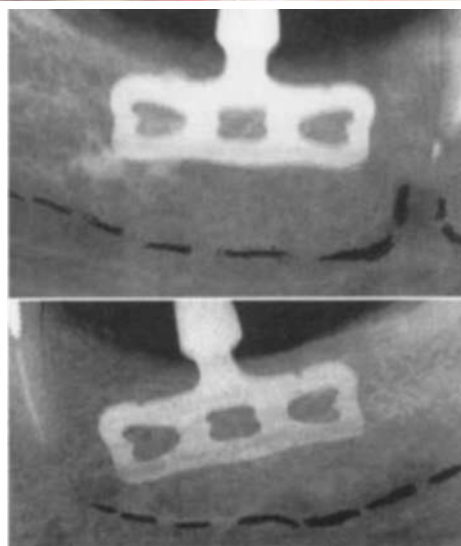
With gentle tapping and full vision, seat the implant until the safety stop at the base of the abutment engages the crest of the ridge (Fig. 13-39). The safety stop prevents overseating and acts as a point of implant stabilization.

The body of a correctly seated implant must fit tightly and securely against the cancellous bone of the narrower osteotomy. No movement is permissible. This tight frictional fit keeps the implant immobile during the early stages of healing.

When the abutment has been bent to a significant angle for parallelism, as is often the case in the maxilla, the base of the safety stop may engage the lingual but not the buccal crest of the bone. Using an XL osteotomy channeling



A



B

FIG. 13-39 ■ A, Correctly seated implants with safety stops against ridge crest. B, Radiographs of correctly seated implants.

bur, reduce the lingual crest under the safety stop. Tap the implant apically with a seating instrument until the safety stop engages both plates of bone.

If there is a firm lingual crest, as is almost always the case, and a more friable buccal crest, the implant may remain seated engaging only the lingual crest. Tap the abutment with the reverse end of a seating instrument to hear the solid ringing sound that indicates the implant is securely and properly seated.

Increasing Primary Retention, If Required. Occasionally an osteotomy is prepared too wide, or is inadvertently widened during repeated preliminary insertions to make adjustments. To ensure retentive stability, the implant can be bent into a mesio-distal curve more acute than the curvature of the arch. This creates a condition for final seating with tight three-point contact, with the mesial and distal implant ends snug against the lingual bone of the osteotomy and the mid-body portion under the abutment snug against the buccal bone of the osteotomy (Fig. 13-40).

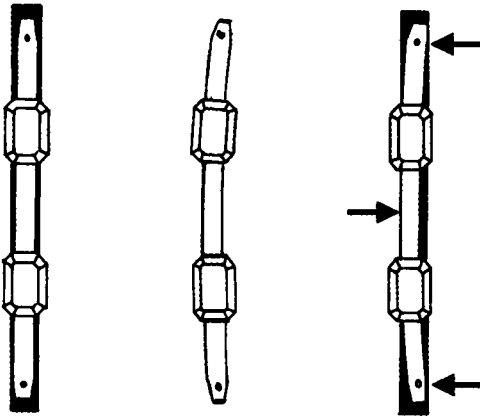


FIG. 13-40 ■ Curvature adjustments to increase primary retention in osteotomy.

That plate/blade form implants are bendable is another unique advantage of this modality. Note that coatings are not recommended for plate/blade implants because they preclude bending adjustments. Coatings may crack, peel, delaminate, promote pit and fissure corrosion, and expose what may no longer be a biocompatible interface. Moreover, in consideration of the success of uncoated plate/blade form implants, coatings cannot be said to offer sufficiently significant advantages for plate/blade form implants.

Postinsertion Soft-Tissue Procedures

If required because of the presence of flabby tissue over the incision site preoperatively, or in the case of excessively thick maxillary gingiva, remove any excess tissue that will interfere with coapting the flaps, decrease flap thickness if required, and reduce flabby tissue according to the procedures and principles described in Chapter 9.

Whether or not these plastic surgery procedures are required, in the case of one-stage implants, tissue punch to remove any tissue that bunches around the collar upon coapting, again according to the procedures described in Chapter 9. When the soft tissue is ready for suturing, take a periapical radiograph for the patient record.

Final Closure—Suturing

Suture according to the principles and procedures described in Chapter 9. For a single-abutment implant, place the first suture just mesial to the abutment. Penetrate first on the buccal flap even with the mesial border of the abutment, pass the needle through the lingual flap at the mid-point of the lingual extent of the abutment, and tie with a surgeon's knot. Penetrate next on the buccal flap even with the distal border of the abutment, pass the needle through the lingual flap at the mid-point of the lingual extent of the abutment, and tie.

This technique snugly wraps the gingival flaps around the abutment. Avoid wound separation during healing by securing a deep bite at each penetration of the needle, into as much of the tougher area of attached gingiva as possible.

In the case of a double-abutment implant, the first suture is placed at the mesial of the mesial abutment, the second at the distal of the distal abutment, the third at the distal of the mesial abutment, and the fourth at the mesial of the distal abutment.

When angled as described for a double-abutment implant, tissue is wrapped snugly around both abutments.

Check Temporization of Premolar Co-Abutments

If the premolar provisional crowns were removed, reseal them and recheck margins, embrasures, and occlusion. Again check for adequate interocclusal clearance of the implant abutment(s). Adjust if required.

The provisional crowns over the natural co-abutments are removed before implant insertion, enhancing visibility and access to the field of operation. In checking the marginal fit, attention is paid to the distal of the nearest natural co-abutment where it was incised. Check the suture in that area, and the marginal fit of the provisional crown.

Select Shade

As discussed in Chapter 9, the practitioner now selects the shade to be used in the restoration. In the teaching case, the shade is used both for a provisional removable prosthesis and for the final fixed bridgework.



FIG. 13-41 ■ Seating of provisional crowns.

Provisional Removable Prostheses

Whenever possible, it is desirable not to use a removable provisional prosthesis over the implant. Avoiding provisional restoration reduces the likelihood of complications. A removable provisional prosthesis may not be needed when treatment is performed in a reasonably nonesthetic area, such as in many posterior cases, and when the patient's temperament can accommodate the absence of replacements during healing. When a provisional prosthesis is required because the implants have been inserted in an esthetic area, or because of patient insistence even when the implants are in a nonesthetic area, the provisional prosthesis must be fitted carefully (Fig. 13-41).

The natural co-abutments help immobilize the provisional prosthesis. The portion of the prosthesis over the implant and the pontic is adjusted to be out of occlusion, and dietary constraints are emphasized. Even the most carefully made provisional prosthesis can be weak, break, or have delicate margins. Any one of these may interfere with healing. Diligent home care is important.

The provisional prosthesis is placed using sedative cement that is applied only to the natural co-abutment crowns. No cement is placed within the provisional crown over an implant abutment. Light frictional fit is adequate.

Applying the sedative cement only to the natural co-abutments protects the implant from being disturbed during healing when a provisional prosthesis is removed to facilitate suture removal.

Postinsertion Home Care Instruction

As discussed in Chapter 9, advise the patient about the effects that can result from the trauma of the surgery, and

BOX 13-4 ■ VISIT 2, WEEK 1: SUTURE REMOVAL AND INTERIM EVALUATION

Conduct general evaluation
Remove sutures
Evaluate soft-tissue healing
Check and adjust co-abutment temporization as required

BOX 13-5 ■ VISIT 3, WEEK 2: MASTER IMPRESSION AND INTERARCH OCCLUSAL REGISTRATION

Expose natural co-abutments
Take master impression
Take interarch occlusal registration
Reconfirm shade

prescribe prophylactic antibiotic and analgesic medications. Instruct the patient in proper postoperative cleanliness, and advise the maintenance of a soft diet to ensure that excessive function of the implant will not interfere with tissue integration.

Visit 2: Postinsertion Follow-Up Visit

As described in Chapter 9, a postinsertion follow-up visit is scheduled for 7 to 10 days after insertion (Box 13-4). At this time, conduct a general evaluation, remove the sutures, evaluate soft-tissue healing, and check and adjust the fit of the provisional prosthesis.

Postinsertion General Considerations

In cases of normal healing, to follow required case sequencing, the next appointment is made 7 to 10 days following suture removal.

This time span allows for further healing of the soft tissues overlying the implant and around the incised gingival cuff of the natural co-abutment before the initial appointment for fabrication of the final prosthesis. Almost always, the site is ready for final impressioning 7 to 10 days following suture removal.

VISIT 3: MASTER IMPRESSION AND INTERARCH OCCLUSAL REGISTRATION FOR PROSTHODONTIC RESTORATION

The steps that are performed during the master impression and interarch occlusal registration visit are shown in Box 13-5.



FIG. 13-42 ■ Master impression for prosthesis fabrication.



FIG. 13-43 ■ Three separate bridges for bisque-bake try-in. Arrows indicate junctures between bridges.

General Considerations

The prosthodontic restoration of mainstream cases using plate/blade form implants as middle or end co-abutments represents an area of significant advantage over other implant modalities. Unlike the prosthodontic restoration of root form cases, plate/blade form restorative dentistry is essentially identical to that of conventional nonimplant cases. One can fabricate the required three- to five-unit fixed prosthesis as if it were intended to be entirely supported by natural abutments. No special courses must be taken, no special laboratories must be used, and no specialized components must be incorporated into the prosthesis. Conventional skills are all that are required.

Although the restorative regimen is conventional, its time sequencing is critical. Awareness of the day-by-day events that occur in the healing cycle following plate/blade form implant insertion helps one clearly understand what is required for successful case completion and optimal prognosis. Plan for complete fabrication of the prosthesis within 2 to 4 weeks.

Master Impressioning/Master Model

Master impressioning and pouring the master model is best accomplished using the techniques one prefers for tooth-supported fixed bridges. Gingival cord usually is used to control bleeding and create space for the elastic impression material of choice. Following impression removal (Fig. 13-42), carefully inspect for and cleanse away any residual material.

Recording Jaw Relationships

It is recommended that one use the same technique to record jaw relationships that one regularly uses in the fabrication of conventional prostheses.

VISITS 4 AND 5: TRY-IN AND ADJUSTMENT OF FINAL PROSTHESIS

The steps that are performed during the visits for try-in and adjustment of the final prosthesis are shown in Box 13-6.



FIG. 13-44 ■ Bisque-bake try-in.

BOX 13-6 ■ VISITS 4 TO 5, WEEKS 3 TO 5: TRY-IN AND ADJUSTMENT OF FINAL PROSTHESIS

Try in bisque-baked bridge directly, or try in copings and/or assembled framework before bisque-bake try-in
Check occlusion, tooth contours, embrasures, and margins, and reconfirm shade

Step-By-Step Prosthesis Fabrication and Time Sequencing

Use conventional techniques to fabricate the prosthesis. Remember that the elapsed time until completion should be 2 to 4 weeks. Some practitioners write their laboratory prescription for a return of an assembled bisque-baked prosthesis try-in (Figs. 13-43 through 13-45). Many try a one-piece frame casting first, and then bisque bake. Still others try in individual copings, assemble them, and then bisque bake and go to completion. The number of required visits therefore varies, but the process should be completed within 2 to 4 weeks no matter what protocol is followed.



FIG. 13-45 ■ Perfecting occlusion at bisque-bake try-in.

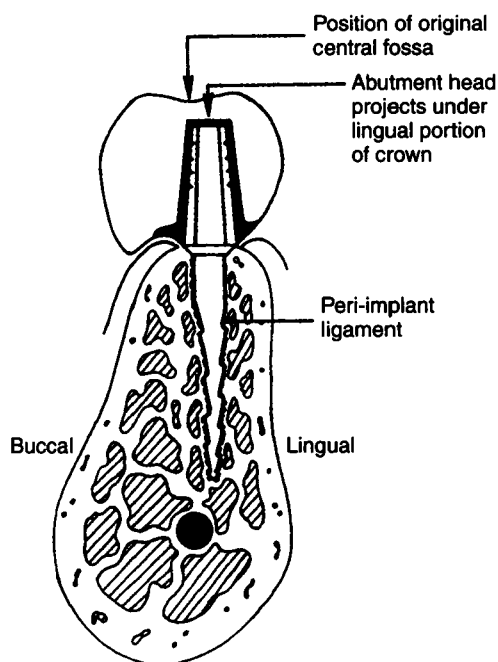


FIG. 13-46 ■ Effect of resorption on relationship between ridge crest and central fossae of the occlusal surface.

Implant-Related Prosthodontic Considerations

Central Fossae/Ridge Crest Relationships. When teeth are removed, resorption occurs at the expense of the buccal and labial plates of bone. Ridges resorb medially, toward the lingual, as they lose height. After healing, the ridge crest is lingual to its original position when the teeth were in position. The implant abutment protrudes through the ridge crest, lingual to the position of the central fossae of the teeth when they were present.

In positioning replacement teeth, the central fossae generally should replicate those of the original teeth to help ensure ideal occlusion, esthetics, and the dimensional and functional integrity of the vestibule. Therefore, properly contoured replacement teeth will be partially labial or buccal to the healed ridge crest, and implant abutments will project under the lingual portion of the overlying crown (Fig. 13-46). In some resorbed posterior maxillary cases, it may be necessary to establish an edge-to-edge occlusion,

or even a crossbite. In more resorbed mandibular cases, occlusion may be established primarily between the tip and buccal incline of the maxillary lingual cusp and the central fossa and lingual incline of an extremely narrow mandibular buccal cusp. Because of resorption patterns, it may be desirable for esthetics, and often for function, to ridge lap the labial or buccal gingival margin of the implant abutment crown, especially in esthetic areas.

Ridge Lapping Implant Abutments. For the esthetic configuration of anterior pontics of conventional fixed bridges, the ridge lap is important. To provide an esthetic lineup of pontics in the area of the gingival margin, a passively placed ridge lap is formed labial or buccal to the ridge crest. These pontics are fabricated to provide esthetic gingival curvature, and appear to be growing out of the gum. In conventional fixed prostheses, only pontics are ridge lapped. Ridge lapping cannot be predictably or successfully accomplished with crowns over teeth. The gingival sulcus of the tooth becomes periodontally involved, no matter how well home care is performed.

This is not true of the abutments in mainstream plate/blade form cases. Although a peri-implant gingival sulcus with **hemidesmosomes** exists, direct fiber insertion into the implant does not occur, as it does into tooth cementum. Nonetheless, in mainstream cases, the implant margin usually is in attached gingiva, and it is thought that this is why ridge lapping in these cases succeeds. Plate/blade form implant prostheses have functioned successfully with ridge-lapped implant abutments for about 30 years.^{6,15,16} This is a boon to the esthetic result and ease of cleansability compared with deep-pocketed emergent profile prostheses. In cases in which the labial or buccal margins of root forms are in attached gingiva, ridge lapping can be performed for this modality as well.

In forming a ridge lap, note that all proximal and lingual implant abutment crown casting margins are created as they would be against teeth. Only the buccal/labial areas are extended (Fig. 13-47). This is best accomplished in the laboratory by esthetically setting replacement teeth as though they were pontics, and permitting the implant abutments to fit whatever location they occupy under the lingual of the replacement crowns, modified by esthetic contouring dictates. As a result, in plate/blade form implantology, although it is desirable to have implant abutments rise through the gingiva at a central point under the overlying crown, it is not hygienically or esthetically essential that they do so. In the area of the ridge lap, place the metal casting margin at or slightly above the gingiva, and extend metal 2 mm shy of the expected edge of the final resin or porcelain ridge lap to allow ample room at try-in visits to adjust for esthetic recontouring without exposing metal.

In nonesthetic areas, ridge lapping is optimal. **Bullet-shaped crowns** with wide embrasures also are often used, depending on practitioner preference and patient acceptance (Fig. 13-48).

Finishing Lines Against Abutments/Embrasures. In the area of the ridge lap, the finishing line of the crown

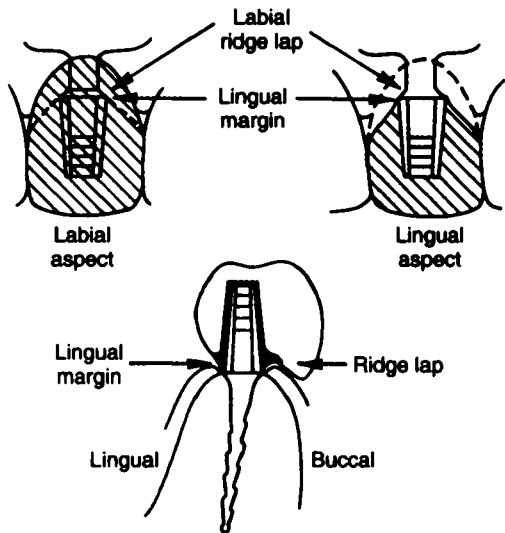


FIG. 13-47 ■ Positioning of ridge lap and crown finishing line over implant abutment.

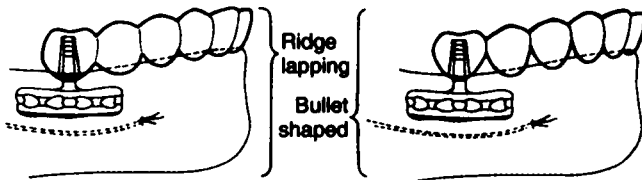


FIG. 13-48 ■ Ridge laps and bullet-shaped crowns.

is placed at or up to 1 mm above the gingival margin, to allow for proper flossing and flow of fluids during lavage. All margins are placed above, at, or below the free gingival crest, in accordance with the same policy used for crowned natural abutments.

Embrasures are also created in accordance with one's preferred fixed bridgework policies. In mainstream plate/blade form implantology, with a few simple options, the overlying prosthesis is conventionally fabricated. Well-made prostheses, as always, are essential to success.

Occlusion. Occlusion is also established in accordance with the techniques and principles one prefers for conventional fixed prostheses. No single technique is best. Narrow bucco-lingual dimensions, anatomic or semi-anatomic noninterfering cusp relations, group function, cuspid protection, long centric, gnathologic principles, and others are successfully used with plate/blade form implants.

Materials. Most materials can be used. Many porcelain-to-metal prostheses have been successfully used, as have gold occlusals with acrylic veneers, and gold superstructures with acrylic teeth. Gold and acrylic occlusal surfaces transmit less functional force than porcelain. These alternative materials are not required in mainstream cases but may be of benefit in cases offering a more marginal prognosis.



FIG. 13-49 ■ Internal surface (A) and intraoral view (B) of the three completed prostheses.

BOX 13-7 ■ VISITS 6 TO 7, WEEKS 6 TO 7: CEMENTATION OF FINAL PROSTHESIS

- Remove provisional restoration
- Try in completed prosthesis
- Check previous adjustments and shade
- Perform provisional cementation
- Evaluate patient comfort and gingival adaptation to pontic and crowns
- Perform final cementation

VISITS 6 AND 7: CEMENTATION OF FINAL PROSTHESIS

The steps that are performed at the visits for cementation of the final prosthesis are shown in Box 13-7.

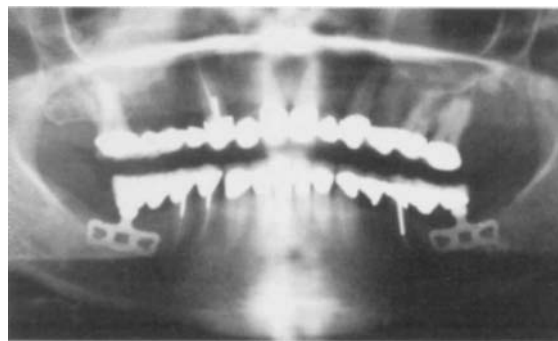
Provisional Placement

The final restoration may be placed provisionally for up to 1 week. No provisional cement is placed over the implant abutment. Conventional placement of provisional cement protects the natural co-abutments.

Final Placement

Check the provisionally cemented restoration. Evaluate the gingiva and adjust the pontic and crowns. If the condition of the soft tissue is acceptable, the final restoration (Fig. 13-49) is seated with one's preferred crown and bridge cement. Zinc oxyphosphate, polycarbonate, and acrylic cements are all successfully used.

FIG. 13-50 ■ Postoperative panoramic radiograph of completed case.



Postoperative Radiographic Record

A postoperative radiographic record is obtained. A simple panoramic radiograph, or a series of periapical radiographs, is sufficient for this purpose (Fig. 13-50).

AFTERCARE AND MAINTENANCE Regimen for Slowly Increasing Function

In osteopreserved cases, the regimen for slowly increasing function of the inserted prosthesis is important. Although the soft tissues are all but fully healed at the time of final restoration, the underlying bone growing through the implant vents and forming the cribriform plate is still maturing, and will reorient its cancellous and cortical components in function in accordance with the direction, magnitude, duration, and character of applied functional forces. In the earliest stages of healing, frictional fit directly against the bone keeps the implant immobile. Seating the final restoration, which splints the implant abutment(s) to natural co-abutments, further ensures immobility during the remainder of the healing period. The final restoration acts as a cast does on a fracture, to ensure an environment that promotes healing. In this case, the “cast” is never removed—the final prosthesis remains in position. The patient remains on the same soft diet advised before insertion of the final prosthesis. Over the next 4 to 6 weeks, the patient should slowly increase the consistency of his or her diet, until regular eating habits are fully resumed. Chapter 6 discusses the healing around osteopreserved implants, and demonstrates that correct case sequencing must be coordinated with the physiologic healing process to ensure long-term health.

As discussed in Chapter 9, professional and home maintenance must be performed regularly and diligently to avoid complications.

COMPLICATING AND ATYPICAL CONDITIONS Common Complicating and Atypical Conditions

The complicating and atypical conditions that are common to the mainstream treatment procedures using any of the abutment-providing implant modalities, as discussed in Chapter 9, are all applicable here. These include questionable adequacy of ridge width, minimal width of

attached gingiva, frayed or torn flaps, excessive bleeding, retained root tip, presence of a cyst or granulomatous tissue, unusual variation in ridge height and/or contours, labial or lingual osseous perforation during osteotomy preparation, fracture of the labial or lingual osteotomy wall, friable tissue at suturing, excessive postoperative edema, and retained impression material. Each of these conditions is rare. Treating these complications properly is discussed in Chapter 9.

Extreme Angle Between Long Axis of Osteotomy and Requirements for Abutment Parallelism

Because of the strength and resistance to fatigue stress afforded by coining during the fabrication of the system used in the teaching case, bending up to 60 degrees across the neck of the implant can be performed safely, without fear of fracture. The prime consideration is biomechanical. In such cases, bone width in excess of 1 mm on either side of the implant is an advantage. When bending for parallelism exceeds 45 degrees, consider additional co-abutment support for the prosthesis. Also, adjust the occlusion to reduce applied forces, and limit contact in lateral excursions.

Minimal Interocclusal Clearance

Further reducing the implant abutment before taking the master impression may alter its cementing surface area to the point at which retention is compromised. If so, a metal stop in the occlusal surface may be a better choice. In such cases, a double-abutment implant may be chosen to increase cementation surface area.

Inadequate Frictional Fit of Implant on Final Placement

Inadequate frictional fit of the implant on final placement is not a problem when using plate/blade form implants. If during preliminary or final implant seating there is any question regarding primary retention, the implant is removed and the body of the implant is slightly curved to increase frictional fit as previously described. There is no rea-



FIG. 13-51 ■ Preoperative (A) and healed (B) two-stage plate/blade form case.

son for inadequate frictional fit of an implant at the time of final seating.

VARIATIONS AND ALTERNATIVES

Semi-Submerged Protected Healing

In nonesthetic areas, such as in most mainstream posterior cases, provisional prostheses that include the inserted implant are not required. For patients with tongue-thrusting habits, or who cannot be trusted to carefully maintain a soft-diet regimen during healing, semi-submerged protected healing with a two-stage implant may be used. On a two-stage implant, the abutment is separable from the body, and is replaced with a healing collar after implant insertion (Fig. 13-51). When the healing collar is removed and the abutment is replaced, the restoration is treated as though the implant were a one-piece, one-stage implant. The healing collar is positioned flush with or up to approximately 1 mm above the gingival crest (Fig. 13-52). Thus, during the earliest healing stages, the chance of excessive force being applied is diminished. Two weeks postinsertion, approximately 1 week following suture removal, the healing collar is removed before the start of prosthodontic restoration. The abutment, already adjusted for parallelism and interocclusal clearance during the course of implant insertion, is test seated and then cemented into position, never again to be removed (Fig. 13-53). This is important, for if after taking the master impression the implant abutment is removed and the healing collar replaced for further protection until the next visit, it becomes extremely difficult to replace the abutment in the precise position that it occupied before taking the master impression. In such cases, the prosthodontic superstructure casting may not fully seat.

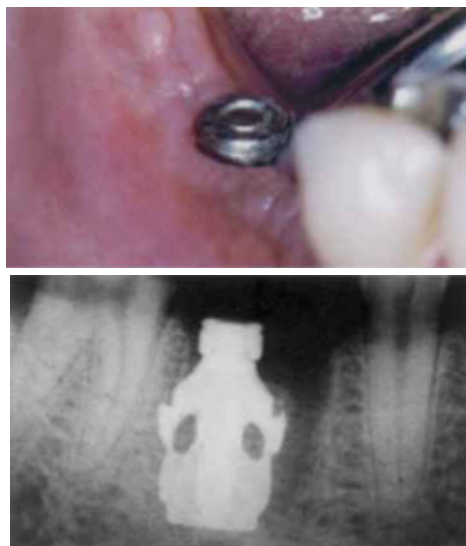


FIG. 13-52 ■ Healing collar in position.



FIG. 13-53 ■ Two-stage plate/blade form universal abutment in position.

Restorative Procedure Options

Several techniques are commonly used for the conventional fabrication of a three- or four-unit fixed prosthesis. Some practitioners have the laboratory return individual copings on the master model. After each is tried in and adjusted, assembly indices are taken, and at the next visit the assembled framework, or even a partially assembled framework, is tried in and adjusted. Once the entire framework is tested, a bisque-bake try-in is used, and finally the completed restoration is seated and cemented. Extra visits are required, but

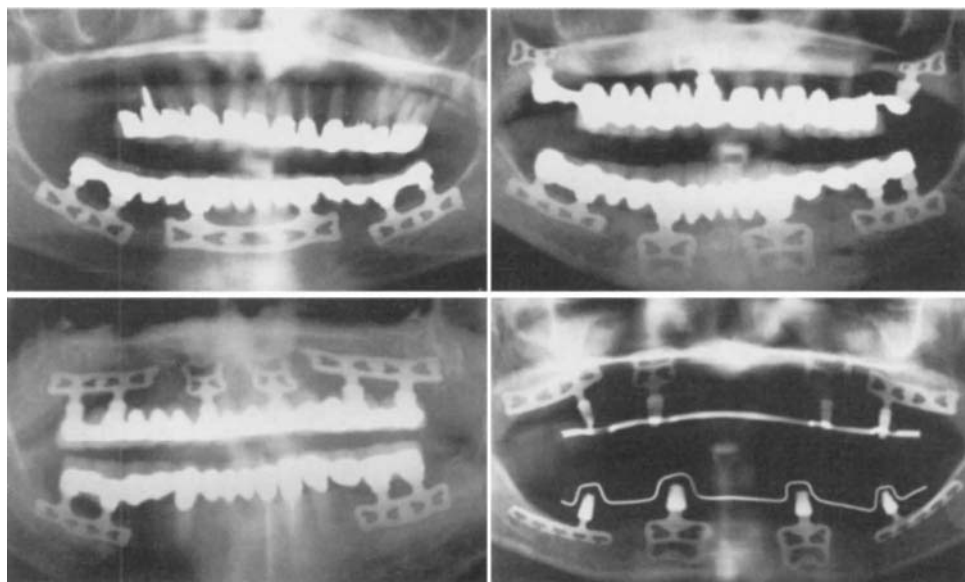


FIG. 13-54 ■ Examples of complete arch restorations totally supported by plate/blade form implants.

this is not problematic as long as the total elapsed treatment time does not extend beyond 6 weeks, or if unavoidable, 8 weeks. Remember that the finally seated, completed prosthesis becomes the “cast” that holds the implant immobile during the weeks in which the patient is slowly increasing function as healing is completed.

Precision and Semi-Precision Attachments

Precision and semi-precision attachments are not required for restorations over one-stage plate/blade forms with natural co-abutments. The tissue integration around the implant and the natural co-abutments is biomechanically compatible.

Stress-Breaking

The use of stress-breaking components in mainstream plate/blade form prostheses may be counterproductive. One objective of the final prosthesis is to provide rigidity, especially during the healing and bone reorientation phase, and shared loading in function. Posteriorly, functional load is up to four times greater than anteriorly. In posterior mainstream cases, the implant is almost always posterior to the natural co-abutments. Use of a stress-breaker protects the natural co-abutments more than the implants, which are subjected to added load. A rigid prosthesis offers the best prognosis.

Screw Retention

The main benefits of screw retention are reentry if complications arise, and dependable prosthesis fixation when minimal occlusal clearance does not provide for adequate

cementation area because of shortened abutments. Given the excellent survival rates of plate/blade form implants, and the option of using a double-abutment configuration in cases with inadequate cementation, some practitioners believe that the use of screws for retention is not worthwhile. Loose or fractured screws are complications that should be avoided.

Implant Insertion in New or Partially Healed Extraction Sites

A plate/blade form can be inserted into an immediate extraction site if the shoulder of the implant passes across the socket, and the safety stop under each abutment head rests securely on healed crestal bone. However, considering the wide range of available plate/blade form configurations, it is not detrimental to allow the extraction site to heal before implantation, even if slight resorption is expected. If necessary, a slightly shallower configuration can be used to accommodate the new dimensions of available bone.

Plate/Blade Form Total Support

Unilateral posterior cases cannot be supported solely by plate/blade form implants. One must at least turn the arch in cases in which natural co-abutments are not used. Complete arch fixed restorations totally supported by one-stage plate/blade form implants have been successfully performed for more than 30 years (Fig. 13-54).

Plate/Blade Form—Root Form Co-Abutments

Some practitioners have achieved acceptable results using a combination of plate/blade forms and root forms under

a prosthesis. In almost all of these cases, the edentulous area encompasses everything distal to the cuspid. In the mandible, a root form is inserted in the first premolar area, and a two-stage osteointegrated plate/blade form is inserted over the inferior alveolar canal, as shown in Fig. 13-2. The practitioner sequences the case for osteointegration of the plate/blade form. Such cases are not considered mainstream.

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14 Unilateral Subperiosteal Implants

Treatment of Partial Edentulism With Severe Alveolar Ridge Resorption Diagnosed for a Fixed Prosthesis With Natural Co-Abutments

BENEFITS AND DESCRIPTION OF THE MODALITY USED IN THE TEACHING CASE

When the volume of the residual alveolar ridge is insufficient to receive endosteal implants, use of the unilateral subperiosteal implant is the treatment of choice¹ (Fig. 14-1). Subperiosteal implants require more maintenance than endosteal implants but have comparable success and survival rates.^{2,3} They were specifically developed to treat patients with insufficient available bone in the alveolar ridge for the insertion of endosteal implants. They should not be used for patients with overabundant bone.

Mode of Tissue Integration

Subperiosteal implants heal in the periosteal mode of tissue integration. They are enveloped in a dense fibrous collagenous tissue sheath constituting the outer layer of the periosteum. Functional forces are absorbed by the underlying bone through the periosteum.^{4,5}

Planning for Treatment

Diagnosis and treatment planning is routine. Periapical radiographs, supplemented by panoramic radiographs if desired, are all that are required. Out-of-office radiography is not required for mainstream cases.

Technique-Permissive Implant Fabrication and Insertion

In many respects, mainstream unilateral subperiosteal implant fabrication and insertion protocols are simpler than those for endosteal implants. The implants are custom made, designed and cast from wax-ups on models of the supporting bone. In mainstream cases these models are

poured from direct bone impressions obtained following tissue reflection. Tissue reflection, though more extensive, is essentially the same as that for endosteal implants. No osteotomy is required. During what is termed the stage one visit, taking the direct bone impression is easier than preparing osteotomies for endosteal implants.⁶ In stage two, following laboratory fabrication of the implant, insertion is simple as well. The entire protocol is technique-permissive.

Restorative Simplicity

In mainstream cases, the final prosthesis is almost always a fixed bridge supported by the unilateral subperiosteal implant posteriorly and natural co-abutments anteriorly. In such cases, the implant abutment, which extends into the oral cavity through attached gingiva, is treated as one would treat the abutment of a plate/blade form implant (Fig. 14-2). The prosthesis is fabricated in the same way, with the same simplicity. The prosthodontics are conventional.⁷

Proven Long-Term Success/Survival Rates

Subperiosteal implants are custom made. They are therefore exempt from Food and Drug Administration (FDA) governance, and not applicable to the American Dental Association (ADA) Acceptance Program, which focuses on manufactured products.⁸ This implant modality has been in wide use for well over 40 years. The ADA Council on Education has declared subperiosteal implantology to be a viable treatment option for correctly diagnosed and fully informed patients in the hands of a trained practitioner. Long-term survival rates are high, although as previously mentioned, maintenance and reversible complication rates are higher than for endosteal implants.⁹ Research confirming these points is presented in Chapter 8.

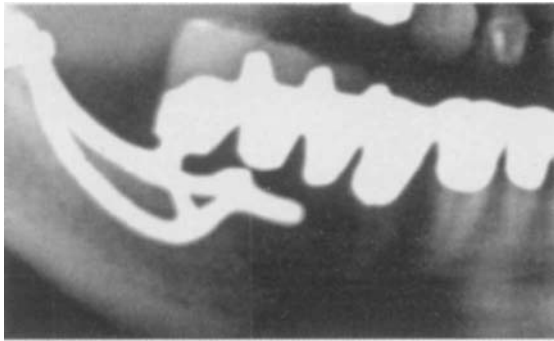


FIG. 14-1 ■ Mainstream unilateral subperiosteal implant serving as a distal abutment for a fixed prosthesis.



FIG. 14-3 ■ Labial/left buccal view of mandibular subperiosteal model.



FIG. 14-2 ■ Abutments of healed mandibular (*left*, note flossing) and maxillary (*right*) subperiosteal implants.



FIG. 14-4 ■ Labial/right buccal view of mandibular subperiosteal model.

Unique Features

Unilateral subperiosteal implants are used with natural co-abutments. Cases can be completed in 4 to 7 weeks of elapsed treatment time. In mainstream cases, fixed bridges are the restoration of choice. One can create posterior abutments in the maxilla within weeks and avoid the invasive, time-consuming protocols for subantral augmentation procedures. In the mandible as well, subperiosteal implant treatment renders bone augmentation, grafting, or nerve repositioning unnecessary. In many severely resorbed edentulous cases, unilateral subperiosteal implantology is the only mainstream abutment-providing treatment that can help the patient.

Configuration and Nomenclature of Subperiosteal Implants

The primary support for subperiosteal implants is derived from main bearing struts that rest over basal bone (Fig. 14-3). Basal bone is defined as the relatively fixed and unchangeable framework of the mandible and maxilla.¹⁰ Alveolar bone, which rests on basal bone, is bone that invested the roots of teeth when they were in position, and transmitted their functional forces. Buccal and lingual main bearing struts are joined by connecting struts, which cross over the resorbed residual alveolar ridge

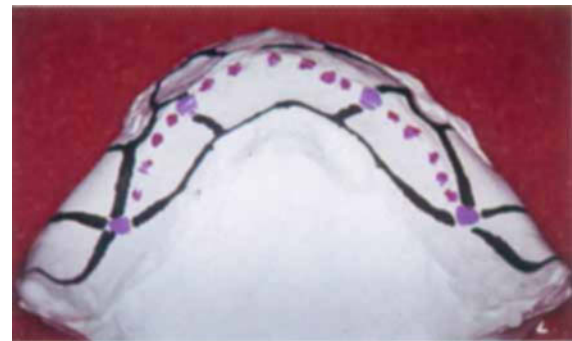


FIG. 14-5 ■ Lingual/crestal view of mandibular subperiosteal model. Dotted line represents ridge crest.

(Figs. 14-4 and 14-5). The implant abutment arises from a connecting strut that provides ideal mesio-distal and bucco-lingual prosthodontic positioning for the planned restoration. In the maxilla, in cases with thick overlying soft tissue, a pergingival strut may be interposed between a connecting strut and the abutment. One or two screw holes may be provided within the main bearing struts, to permit insertion of bone screws that enhance initial fixation of the implant during early healing. These screws may remain in position passively or be removed, their

function accomplished. Specific configurations of abutments and the anatomy of struts are discussed later in this chapter.

Incorporating Unilateral Subperiosteal Implant Dentistry into One's Practice

As a rule, subperiosteal implantology should be pursued after a practitioner has performed mainstream treatment in several cases using the abutment-providing endosteal implant modalities. Unilateral subperiosteal implants are applicable in a smaller percentage of cases, but this minority is of great importance, for these patients have lost not only their teeth but also most or all of their residual alveolar ridge. Also, in most cases in which mainstream treatment can be performed using a unilateral subperiosteal implant, no other abutment-providing modality can offer mainstream treatment.

DIAGNOSIS, TREATMENT PLAN, AND END RESULTS

Case as Presented

Patient's Story. A typical case presents with posterior edentulism, either in the maxilla or mandible. As in mainstream cases correctly diagnosed for endosteal implants, the patient may have a removable unilateral or bilateral free-end saddle partial denture that is prone to complications because of significant ridge resorption. Complaints associated with clasped or semi-precision or precision-attached natural abutments are common. Odor, poor function, gingival tissue complications, and compromised esthetics often lead to implant treatment. Removable appliances may not be well tolerated, and patients may wish not to wear one when they become aware that alternatives exist. One often observes loss of function, sunken hollow cheeks, and reduced facial height.

Clinical Appearance. Examination reveals what is observed in endosteal implant candidates, but often more severely because cases suitable for subperiosteal implant treatment exhibit more bone resorption. Potential natural co-abutments may be more traumatized and require careful evaluation. The edentulous portion of the alveolar ridge is severely resorbed, hollowed out, and flat in the mandible. Edentulous areas in the posterior maxilla are more variable. Sinuses may be deep and quite near the crest, and yet clinically the ridge may appear to be large, full, and broad as a result of the presence of a substantial amount of overlying soft tissue. It is not unusual to see shallow, flat ridges and excessive interocclusal clearance. Another factor to consider is that the buccal plate in the highly resorbed maxilla has lost a substantial amount of bone. Thus, the position of the healed ridge crest is lingual to the opposing dentition, whereas it was once buccal. This poses occlusal challenges in restoring function, such as the potential need to establish an edge-to-edge or cross-bite tooth arrangement, as well as possible esthetic problems. All such difficulties can be overcome.

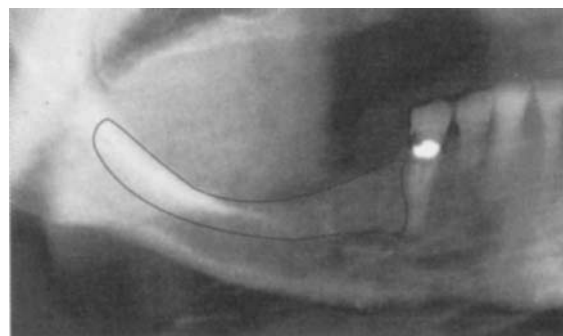


FIG. 14-6 ■ Limited available bone (*outlined*) ideal for placement of unilateral subperiosteal implant.

BOX 14-1 ■ VISIT-BY-VISIT TREATMENT OBJECTIVES

Preoperative procedures

Visit 1: Stage one direct bone impression and interarch occlusal registration for implant fabrication

Visit 2, week 1: Suture removal

Visit 3, week 2: Stage two implant placement

Visit 4, week 3: Suture removal

Visit 5, week 4: Master impression and interarch occlusal registration for prosthesis fabrication

Visits 6 to 7, weeks 5 to 7: Fabrication, try-in, and adjustment of final prosthesis

Visits 8 to 9, weeks 8 to 9: Cementation of final prosthesis

Radiographic Interpretation. The radiograph reveals severely resorbed residual alveolar ridges, with insufficient bone for the insertion of endosteal implants (Fig. 14-6). Landmarks and borders are clearly shown. Inconsistent overlying soft-tissue thickness is observed in both the maxilla and mandible.

Rejected Alternative Treatment Plans

The patient feels that neither adjustments to an existing removable prosthesis nor the fabrication of a new one would be satisfactory. The status quo is also not acceptable, because conditions causing the patient complaints would remain and become exacerbated over time. Implant support and fixed prostheses are desired, yet no endosteal implant modality is indicated because of insufficient available bone. Extensive bone augmentation, subantral augmentation, and nerve repositioning are not mainstream options.

Accepted Treatment Plan—An Overview of Visit-By-Visit Case Sequencing

The objectives of each of the treatment visits for the teaching case in this chapter are shown in Box 14-1. It is important to have a basic understanding of the entire course of treatment, so that one can appreciate how each treatment step contributes to ultimate success.

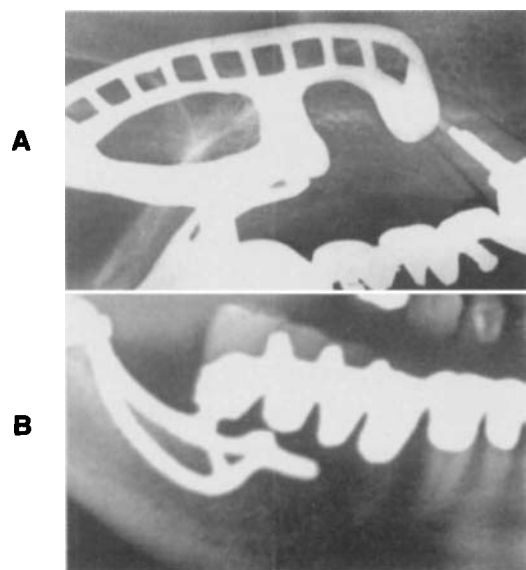


FIG. 14-7 ■ Postoperative radiographs of maxillary (A) and mandibular (B) unilateral subperiosteal implants.

Completed Case

Having the goal of treatment firmly in mind during each patient visit is important. Every procedure is directed toward successful completion of the case. For this reason, the end result is presented here, to help the reader understand how each step of treatment contributes to the final objective, and to convey the satisfaction and benefits of treatment for the patient and the practitioner.

Patient's Story. The treatment goals have been achieved. Nonremovable tooth restorations are in function. The patient is comfortable, with an easily cleansable restoration that is efficient and does not interfere with normal control of speech and salivation. The patient is pleased and grateful.

Clinical Appearance. The completed restoration resembles a conventionally fabricated fixed bridge supported exclusively by natural abutments. Because of the significant ridge resorption that prompted the treatment, the first molar pontic and second molar co-abutment may exhibit greater clinical crown height than usual. Rarely does this interfere with the esthetic result. Because the implant abutment's pergingival site is within attached gingiva, ridge lapping is easily achieved, yielding significant esthetic advantages.¹¹ If the second molar overcasting is in a non-esthetic area, one may elect to fabricate a bullet-shaped pontic rather than ridge lap.⁷ Taking into account the patient's desires when making this choice is advisable.

Radiographic Interpretation. The postoperative radiograph reveals a well-positioned, fully seated implant. The landmarks and borders limiting the extent of the implant are not abridged. The prosthetic restoration has correct margins against both the implant abutment and natural co-abutments. The postoperative radiograph reveals harmony of the axial inclination of the implant and natural co-abutments, the result of careful planning and execution of treatment (Fig. 14-7).

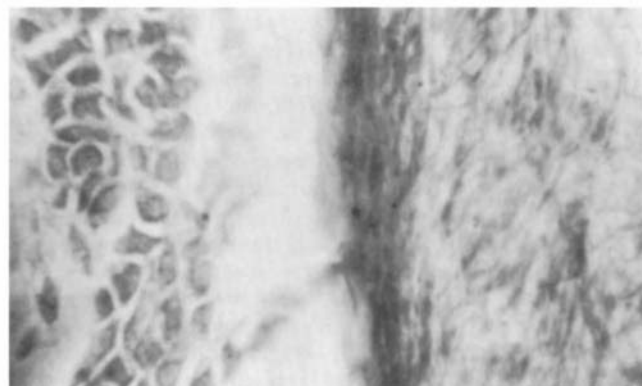


FIG. 14-8 ■ Periosteal tissue integration. (From McKinney RV, Lemons JE, editors: *The dental implant*, Littleton, Mass, 1985, PSG Publishing.)

BOX 14-2 ■ PREOPERATIVE PROCEDURES

- Prepare and temporize natural co-abutments
- Choose single- or double-abutment option
- Evaluate interocclusal clearance
- Prescribe preoperative medication

Microscopic Interpretation at the Interface. Light microscopy following healing reveals a dense fibrous sheath constituting the outer layer of the periosteum enveloping each implant strut. This organized fibrous envelopment, acting as both attachment mechanism and shock-absorbing agent to protect the supporting osseous tissue, is an example of the periosteal mode of tissue integration¹² (Fig. 14-8). A detailed explanation of periosteal tissue integration is given in Chapter 6.

PLANNING AND PROCEDURES BEFORE IMPLANT FABRICATION

The steps that are performed before the implant fabrication visit are shown in Box 14-2.

Prepare and Temporize the Natural Co-Abutments

The natural co-abutments that are used in conjunction with the unilateral subperiosteal implant for support of the restoration are prepared and temporized before direct bone impressioning, often during the same visit under the same local anesthetic. In one's first few cases, it may be advisable to prepare and temporize the natural co-abutments in a separate session before the direct bone impressioning

visit. In cases being referred to another practitioner for implant fabrication, the referring practitioner should prepare and temporize the natural co-abutments before the referral. This gives the inserting practitioner guidance for parallelism when viewing the prepared teeth, and allows greater visibility of and access to the surgical field.

Natural co-abutment preparation and temporization is the same as that for conventional fixed bridgework. Use of one's preferred conventional technique is recommended.

Single- and Double-Abutment Options

Many of the considerations in determining whether to use a single- or a double-abutment plate/blade form apply to subperiosteal implant treatment. An important concern is to ensure that each abutment is placed under a crown of the planned prosthesis. Each abutment should pass through its pergingival site into the oral cavity to harmonize with the opposing dentition, dictating the positioning of the teeth in the planned prosthesis. Insofar as possible, abutments should not be located in embrasures. This is not difficult to achieve in mainstream cases.

The use of two abutments usually is indicated in cases in which the interocclusal clearance is relatively small, resulting in compromised abutment height. Using two abutments in such cases doubles the cementation area, improving retention.

Every subperiosteal implant is uniquely configured. Therefore, preoperatively, one simply determines whether to fabricate the implant with one or two abutments. This influences the design phase, when one determines the exact location of the connecting strut(s) from which the abutment(s) will arise. This and other design considerations are discussed later in this chapter.

Evaluate Opposing Occlusal Plane for Adequate Interocclusal Clearance

In the case of unilateral subperiosteal implants, because ridge resorption is severe, there is almost always adequate interocclusal clearance to enable fabrication of an abutment with sufficient surface area to provide reliable cement fixation for the final prosthesis. One exception occurs when the opposing dentition, over time, has extruded into the edentulous area. One must then shorten extruded teeth as conservatively as possible. In extreme cases, these teeth may require endodontic treatment for this purpose. These considerations are discussed with the patient during the case presentation. Perhaps the greatest benefit of bringing extruded teeth back into a harmonious relationship with the more anterior occluding teeth is the enhanced capability of fabricating a more optimal restoration in terms of function, esthetics, and cleansability. Because the unilateral subperiosteal implant is custom made, it is fabricated with abutments of ideal interocclusal clearance, so adjustment rarely is required.

Prescribe Preoperative Medication

Prescribe preoperative medication for the insertion visit as discussed in Chapter 9. Recall that preoperative administration of anti-edema medication is generally not required for mainstream cases, unless the patient's history suggests that edema may be greater than normal. Nor is preoperative sedation recommended. Patients who take prophylactic aspirin daily are advised to discontinue doing so for at least 3 weeks preoperatively, to allow for normal clotting at the insertion visit.

PRINCIPLES OF MAINSTREAM SUBPERIOSTEAL IMPLANT DESIGN

Osseous Exposure and Evaluation of Available Bone

Because the primary support for subperiosteal implants is provided by main bearing struts that rest on basal bone, tissue reflection for adequate osseous exposure is essential. Underexposure compromises the ability to design an ideal implant. Overexposure may lead to unnecessary tissue trauma, bleeding, edema, and postoperative discomfort. The solution is to design the implant mentally as tissue is reflected. When reflecting the buccal flap to expose to the level of basal bone, stop when enough basal bone is visible in terms of length and depth to permit the placement of an ideal main bearing strut in that area (Fig. 14-9). The same principles apply when reflecting to locate the lingual main bearing strut, connecting struts, and pergingival struts (Figs. 14-10 and 14-11). One must evaluate while exposing the osseous implant support structures whether enough support can be designed to ensure that the final implant will function within physiologic limits of health.¹³

Anatomy of Resorbed Edentulous Alveolar Ridges

In the posterior mandible, the residual alveolar ridge is at least two thirds resorbed. In extremely resorbed cases, the medial border of the edentulous area may be higher than the ridge crest, which may be resorbed to concavity (Fig. 14-12). The inferior alveolar nerve may be dehiscence through the roof of the canal (Fig. 14-13). The relationship between the mental foramen and the inferior border of the mandible, for all clinical purposes, remains fairly constant. Resorption occurs at the expense of the alveolar ridge, at times to the point at which the mental foramen appears at or near the ridge crest (Fig. 14-14). The ascending ramus, mylohyoid ridge, and portions of the lateral border of the ramus are other limiting landmarks for mainstream subperiosteal implants (Fig. 14-15). Compared with ridges that have adequate available bone for endosteal implant insertion, mandibular ridges appropriate for mainstream subperiosteal implants exhibit greatly reduced bone contours. Dehiscence of the nerve makes the treatment non-mainstream.¹⁴

The maxilla is far more variable. Resorption often is greater than in the mandible (Fig. 14-16). Other times, a



FIG. 14-9 ■ Buccal main bearing strut at extent of reflection (*arrows*).



FIG. 14-10 ■ Lingual main bearing strut at extent of reflection (*arrows*).

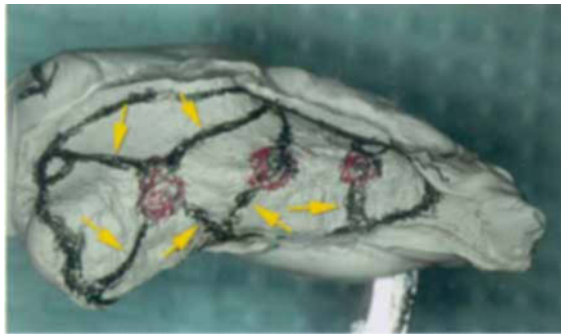


FIG. 14-11 ■ Ideal positioning of connecting struts (*arrows*).

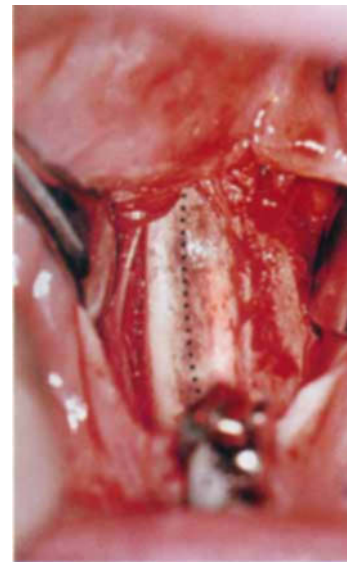


FIG. 14-12 ■ Resorbed ridge crest (*dotted line*) inferior to medial border of mandible.

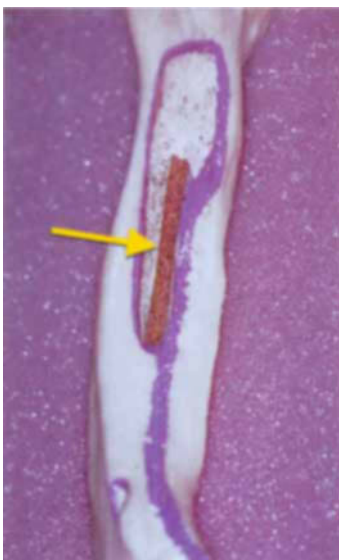


FIG. 14-13 ■ Crestal dehiscence (*arrow*) of inferior alveolar nerve.

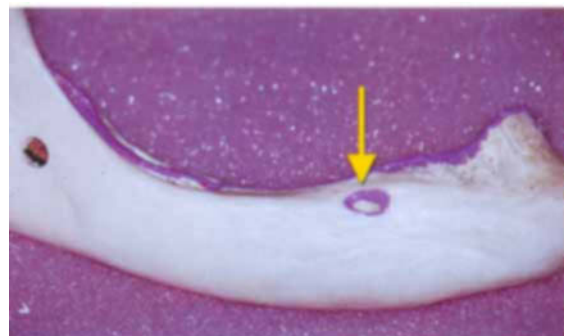


FIG. 14-14 ■ Mental foramen (*arrow*) near ridge crest in severely resorbed mandible.

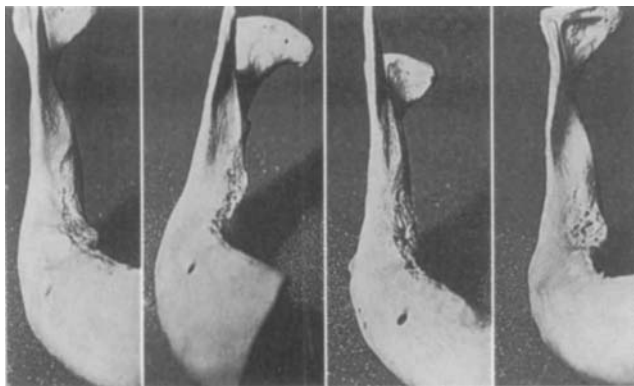


FIG. 14-15 ■ Variations in anatomy of ascending rami.



FIG. 14-17 ■ Broad maxillary ridge.



FIG. 14-16 ■ Severely resorbed maxillary ridge.

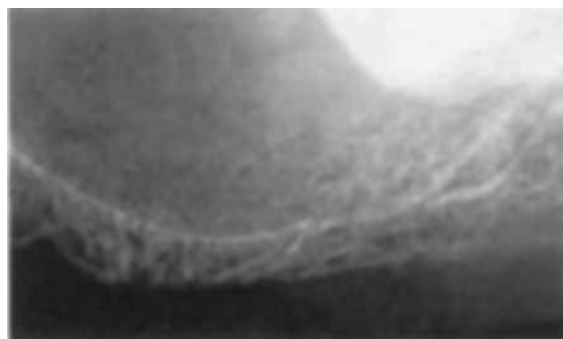


FIG. 14-18 ■ Radiograph showing minimal bone depth under sinus.

clinically full or even wide ridge is observed (Fig. 14-17) that reveals little bone below the base of the sinus radiographically, thus making the case ideal for mainstream subperiosteal implant treatment (Fig. 14-18). In the maxilla, because of the variability of resorption, there may be a well-defined tuberosity with a firm distal border (Fig. 14-19), or little or no residual tuberosity (Fig. 14-20). Toward the distal of the hard palate, slightly medial to the junction of the hard palate and the alveolar ridge, the posterior palatine foramina are located. These provide passage for the blood and nerve supply to the palate, and are to be avoided.

Main Bearing Struts Defined

Main bearing struts of a unilateral subperiosteal implant absorb the functional forces applied to the overlying prosthesis. There are buccal and lingual main bearing struts. They are placed against basal bone.

Connecting Struts Defined

Connecting struts connect and unify the buccal and lingual main bearing struts into a cohesive functioning unit. They usually are placed to cross over residual alveolar ridges.



FIG. 14-19 ■ Tuberosity with sufficient distal border to place a main bearing strut.



FIG. 14-20 ■ Tuberosity with extensively resorbed distal border.

Pergingival Struts Defined

Pergingival struts pass from connecting struts through the overlying soft tissues, preferably through attached gingiva. They are contiguous with the implant abutments.

Abutment Design Options

In many cases the base of the abutment is actually against the connecting strut. The base of the abutment rests on or slightly buccal or lingual to the ridge crest, depending on the preferred prosthodontic positioning. The abutment is best designed to be octagonal, faceted, and tapered to enhance cement retention. Millimeter adjustment lines are

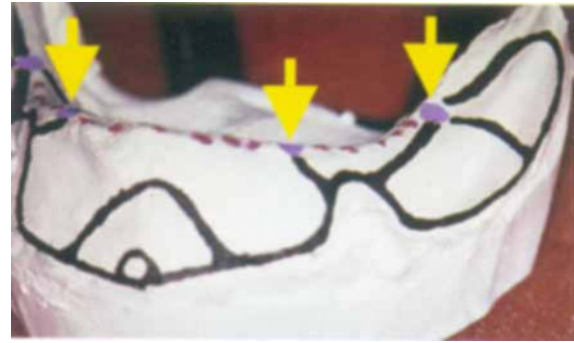


FIG. 14-21 ■ Arrows in the direction of vertical force components.

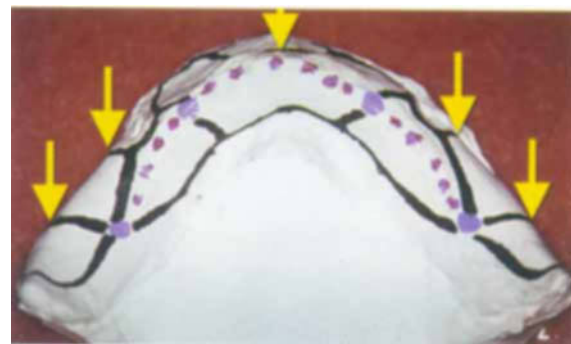


FIG. 14-22 ■ Arrows in the direction of posterior force components.

not needed because the implants are custom fabricated for ideal interocclusal clearance.

Functional Force Components Defined

Functional forces are transmitted through the overlying prosthesis and the implant for ultimate absorption by supporting bone. These functional force components are multidirectional, depending on the occlusal anatomy of the final prosthesis and the dynamics of the chewing cycle, and on whether the implant is in the posterior maxilla or mandible. The basic functional force directions are vertical, anterior, posterior, right lateral, and left lateral. For clarity, the figures related to this discussion of force components and strut placement show models of total arch subperiosteal implants.

Vertical Force Components Defined. The vertical component of applied functional force is applied approximately in the long axis of the residual ridge. It tends to compress the implant firmly over bone during function (Fig. 14-21).

Anterior and Posterior Force Components Defined. The anterior and posterior functional force components act to displace the implant anteriorly or posteriorly during function. Appropriately placed main bearing struts absorb these force components to prevent displacement (Fig 14-22).

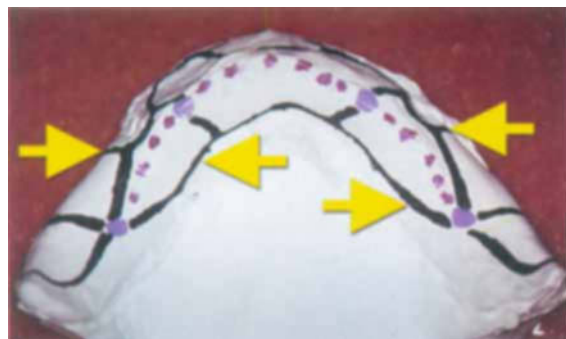


FIG. 14-23 ■ Arrows in the direction of right and left lateral force components.

Right and Left Lateral Force Components Defined. Right and left lateral functional force components act to dislodge the implant toward the right or toward the left (Fig. 14-23). Appropriately placed main bearing struts prevent this.

Locations of Main Bearing Struts to Absorb the Components of Force

The decisions made at the time of implant design are critical to the implant prognosis.¹⁵ In the right mandible, the buccal main bearing strut is positioned to withstand both vertical and left lateral force components. The lingual main bearing strut withstands vertical and right lateral force components. When possible, a forward extension of the lingual main bearing strut is positioned anteriorly to pass to the point at which the mandible narrows, or turns the arch, to withstand the anterior force component. The buccal and lingual main bearing struts diverge as they extend distally, thereby resisting the distal component of functional force. Connecting struts may initially help resist some or even all of the force components, but because of the possibility of continuing alveolar ridge resorption, they cannot be relied upon to do so long-term. Main bearing struts on the anterior portion of the lateral surface of the ascending ramus may help resist the left lateral force component. These struts may be in shear during the exertion of vertical force components, and their action during mandibular flexion is undetermined. In all but the most resorbed mainstream unilateral mandibular subperiosteal cases, struts against the lateral surface of the ascending ramus may be unnecessary.

In the posterior right maxilla, the buccal main bearing strut is positioned superiorly on the lateral border of the temporal bone, against the inferior border of the zygomatic arch. This strut withstands left lateral forces as well as vertical forces. If a distal surface is present on the tuberosity, a buccal main bearing strut is extended around it to connect with the lingual main bearing strut, to absorb anterior force components. The lingual main bearing strut is positioned at the junction of the hard palate and the resorbed alveolar ridge, anterior to the posterior palatine foramina. This strut counters vertical and right lateral force components. The

posterior force component is absorbed by the anterior border of the zygomatic arch, against which the buccal main bearing strut is placed as it extends anteriorly from the inferior border of the zygomatic arch.

Location of Connecting and Pergingival Struts

In the mandible, the first connecting strut location to be designed is the one that gives rise to the pergingival strut and abutments. This is positioned as close as possible to where the second molar abutment for the final prosthesis would be most optimally located. Place connecting struts in depressions or valleys in the edentulous ridge anatomy, where they will be protected, and/or in areas of maximum resorption to minimize the chance of complications related to a change in residual alveolar ridge contours. Other connecting struts for strength and support are placed from buccal to lingual, over residual ridges in areas of maximum resorption and/or depressed areas of bone.

Sectional Contours and Dimensions of Struts

Main bearing struts are generally ribbonlike in configuration. They are generally 1 mm thick, 2 to 3 mm wide, have rounded edges, and a flat base that rests against bone. In some anatomic locations, a main bearing strut must be designed to absorb various functional force components. For example, a main bearing strut passes under the zygomatic buttress to absorb the vertical force components, and proceeds toward the canine fossa to absorb right and left lateral force components. This is also the case with main bearing struts passing along the hard palate as it joins the residual alveolar ridge. Connecting struts are also generally ribbonlike in configuration. Their base lies against the residual alveolar ridge. Connecting struts are generally 1 mm thick and approximately 2 mm wide. In cases in which the overlying soft tissue is only 1 to 2 mm thick, as is commonly observed in the mandible and less often in the maxilla, no pergingival strut is required. In such cases, the connecting strut melds directly with the abutment. When at least 3 mm of soft tissue is present, a round pergingival strut, generally 1.5 to 2 mm in diameter, arises from a connecting strut and broadens to form the same configuration as the safety stop found at the base of a plate/blade form abutment. The safety stop configuration is positioned to be at least 2 mm beneath the gingival crest, and functions in the same manner as an emergence profile collar for certain root form implant systems. Following loading, it is optimal when the tapered, faceted sides of the implant abutment pass to a depth of approximately 2 mm beneath the gingival crest.

VISIT 1: STAGE ONE DIRECT BONE IMPRESSIONING

The steps that are performed during the stage one direct bone impressioning visit are shown in Box 14-3.



FIG. 14-24 ■ Selection of instruments for use during direct bone impressing visit.

BOX 14-3 ■ VISIT 1: STAGE ONE DIRECT BONE IMPRESSION AND INTERARCH OCCLUSAL REGISTRATION FOR IMPLANT FABRICATION

Confirm use of prophylactic antibiotic
Set up instrumentation
Administer anesthetic
Make incision
Reflect tissue
Fix tissue flaps for impressing access
Take one-piece direct bone and opposing arch impression in centric occlusion for implant fabrication
Cleanse and inspect impressed area
Release flap fixation sutures
Suture
Provide home care instruction
Schedule follow-up visit

Confirm That Preoperative Medication Has Been Taken

As discussed in Chapter 9, it is not necessary to postpone the case if the patient has not taken his or her preoperative prophylactic antibiotic medication. The practitioner should have antibiotics on hand for preoperative administration in such cases. If a patient on an aspirin regimen has not discontinued its use, treatment may nonetheless be performed, with delayed clotting expected.

Instrumentation Setup— The Armamentarium

The sterilized instrument setup is placed in the operating area. In contrast with endosteal implant insertion procedures, only one tray setup is required. It consists of a mirror and explorer, scalpel (No. 15 blade preferred), regular and large periosteal elevators, tissue scissors, bone rongeurs, bone file, curette, needle holder, 3-0 atraumatic black silk sutures, needle forceps, suture scissors, tissue retractors, topical anesthetic, local anesthetic and syringes with appropriate needles, a supply of gauze squares, and suction tips (Fig. 14-24).

Presurgical Treatment

Prepare the surgical field, administer local anesthetic containing vasoconstrictor to promote comfort and control bleeding, and prepare the oral cavity and targeted tissues according to the principles and procedures described in Chapter 9.

Incision

Evaluate the attached gingiva, plan the incision line, incise, and ensure hemostasis according to the principles and procedures described in Chapter 9.

To take a stage one direct bone impression for a subperiosteal implant in the mandible, the incision is made through the retromolar pad to the base of the anterior wall of the ascending ramus. It extends anteriorly along the ridge crest to the distal of the most distal remaining tooth. In the maxilla, the incision starts against the distal of the tuberosity, with care to incise buccal to the pterygomandibular raphe, and extends anteriorly along the crest of the alveolar ridge through the distal of the most distal remaining tooth.

Tissue reflection for direct bone impressing for subperiosteal implant design and placement requires wider access than that required for endosteal implant insertion.

Tissue Reflection and Preparation Before Stage One Direct Bone Impressing

Reflect the tissue using the periosteal elevator, trim the tissue flap edges to ensure healing by primary intention, and cleanse and alter the exposed alveolar ridge as required according to the procedures and principles described in Chapter 9.

To take a direct bone impression for the design of a subperiosteal implant, and for its subsequent placement, the extent of tissue reflection is greater than that required for endosteal implants. On the lingual of the mandible, extend the reflection inferiorly until the mylohyoid ridge is exposed to the extent that its inserting mylohyoid muscle fibers can be observed. Extend the lingual reflection distally until the anterior wall of the ascending ramus is visi-

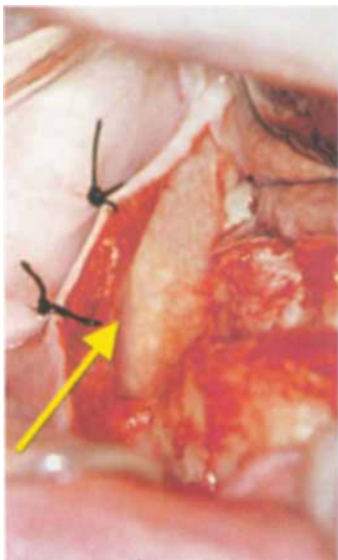


FIG. 14-25 ■ Reflection of buccal flap to base of mandible (arrow).

ble, and mesially until the lingual gingival cuff around the closest natural co-abutment is reflected halfway around the tooth. Reflect the tissue to expose bone inferior and anterior to the anterior border of the mylohyoid ridge.

At the time of reflection, one must think of the main bearing strut that will be placed on the exposed bone, exactly where it will be placed, and whether enough bone is exposed to place it properly. The main bearing strut starts anteriorly below the level of the mylohyoid ridge against the bone opposite the lingual of the natural co-abutments, and passes superiorly at the anterior border of the mylohyoid ridge to cross over into the depression just buccal to the ridge crest.

The buccal mandibular flap is extended down toward the base of the mandible (Fig. 14-25). Distally expose the bone at the ascending ramus and its lateral surface no more than 10 mm posterior to the lateral border of its anterior ascending wall. Carefully reflect mesially until the mental foramen is visualized.

Visualize the design of the buccal main bearing strut. Is there enough exposure to place it over basal bone? If struts on the lateral anterior portion of the ascending ramus are required, is sufficient bone exposed? Is there room over the mental foramen, with 2 mm clearance, to place an anterior extension of the buccal main bearing strut, if required? The object is to design the implant mentally while reflecting tissue.

In the posterior maxilla, the lingual flap is reflected only down to the junction of the hard palate and the alveolar ridge to avoid the posterior palatine foramina. Expose the distal of the tuberosity.¹⁶ About 10 mm anterior to the tuberosity, the reflection may be carried onto the hard palate approximately 5 mm toward the median suture (Fig.



FIG. 14-26 ■ Reflection of distal of tuberosity and junction of alveolar ridge with hard palate (arrows).

14-26). This reflection is carried anteriorly toward the closest natural co-abutment, and ends no farther anteriorly than its mesial border.

The lingual main bearing strut is placed at the junction of the hard palate and alveolar ridge, with a distal portion positioned against the distal of the tuberosity if enough osseous structure exists there to do so, and a mesial extension against the lingual of the alveolar ridge opposite the closest natural co-abutment.

The buccal maxillary flap is reflected until the inferior border of the zygomatic arch is exposed (Fig. 14-27), and then its distal border is exposed as one reflects tissue distally to expose the buccal and disto-buccal of the tuberosity. Reflecting mesially, the mesial border of the zygomatic arch is exposed, and moving superior and mesial to it, bone is exposed anteriorly to the mesial border of the closest natural co-abutment.

Continue to design mentally as tissue reflection proceeds. The labial main bearing strut starts distally at the distal of the tuberosity, if osseous structure exists there, and continues anteriorly and superiorly to the distal of the zygomatic arch, where it passes inferiorly and anteriorly under the arch to proceed superiorly and anteriorly against the buccal bone opposite the root of the closest natural co-abutment. The bone for the design of all other struts is exposed according to this procedure, and will therefore be evident on the master model poured from the direct bone impression.

Tissue Flap Fixation for Enhanced Impressioning

Hold the buccal tissue flap against the cheek. With a 3-0 black silk suture with an atraumatic needle, attach the edge of the flap to the inner surface of the cheek with care-

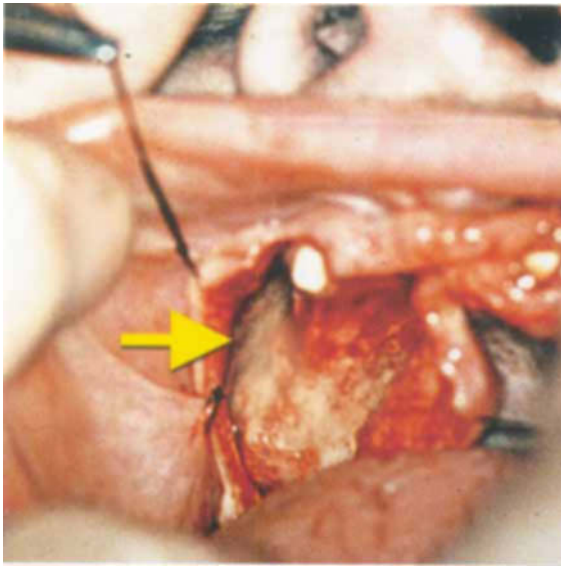


FIG. 14-27 ■ Reflection to inferior border of zygomatic arch (arrow).

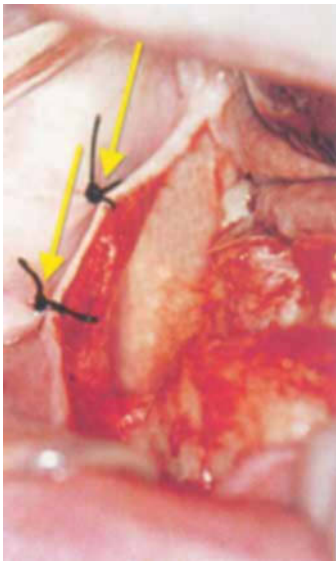


FIG. 14-28 ■ Suture fixation (arrows) of buccal flap to cheek to facilitate direct impressioning.

fully placed sutures spaced 5 to 10 mm apart. Pass the needle through the mucosal lining of the cheek (Fig. 14-28). Avoid the area at the opening of Stenson's duct.

Suturing the tissue flap to the inner surface of the cheek facilitates impressioning the buccal basal bone exposed for the placement of main bearing struts.

Gently grasping the cheek between thumb and forefinger and extending it laterally draws the attached buccal flap with it, resulting in wide exposure of bone. This reduces the chance of tissue interference as impression material is introduced for the direct bone impression.

The lingual flap is held open with a series of sutures that wrap around teeth on the opposite side of the arch, or pass through the gingiva in an edentulous area on the opposite side of the arch. In the latter case, infiltration with a few drops of local anesthetic is advised.

Holding the lingual flap open in this manner facilitates impressioning the lingual aspect of the exposed bone, again opening the area wide and precluding loose tissue from becoming incorporated in the impression material.

The exposed areas are kept moist with coolant.

One-Piece Master Impression of Exposed Bone, Opposing Dentition, and Jaw Relation for Implant Design

With the flaps properly fixed away from the impressioning area, have the patient close in centric occlusion. Observe how the remaining teeth meet clinically, particularly in the areas that are not being impressioned.

This rehearsal is important. One is able to confirm that the patient will close into the desired occlusal relationship when the master bone impression is taken.

Position the patient horizontally to take advantage of gravity during the introduction of impression material. Set up two separate mixes. Inspect the exposed moistened bone, and retract the cheek to rehearse and determine the direction of lateral cheek movement that retracts the buccal flap best for access. Remove the provisional crowns from the natural co-abutments, and cleanse. Mix the first batch of impression material. Insert the impression material into the buccal space, then over the ridge, and then lingually using gentle finger pressure.

A fine impression material is Kerr Citricon heavy body silicone. It is stiff enough when set that it becomes its own tray. Setting time is controlled by adding the desired amount of accelerator at room temperature.

The first batch is portioned to set slowly. The practitioner may insert the bulk of the material first toward the buccal, then over the crest, and then lingually. If some areas are hard to impress, pieces of impression material may first be inserted directly into these areas, and then the bulk of the first impression material mix can be placed. They will merge. Include the prepared natural co-abutments in the impression.

While the initial mix is being inserted against the exposed bone, have the second batch mixed. Add enough accelerator such that it will set faster than the first batch. As the practitioner completes seating the first batch, the second batch should be ready for use.

Place the second batch, rolled into a tubelike shape, over the first batch, and have the patient close down firmly into and maintain centric occlusion (Fig. 14-29). Compress the softer second batch against the setting first batch to join them together. With gentle finger pressure, compress the buccal impression material against the opposing dentition.

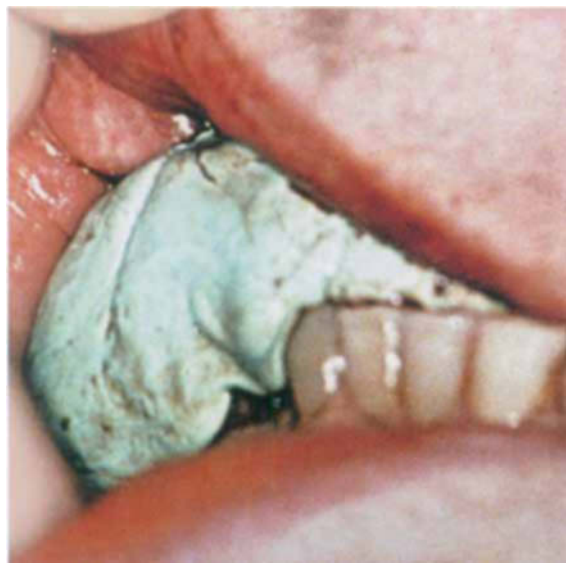


FIG. 14-29 ■ One-piece direct bone impression and opposing dentition in centric occlusion.

Closing into centric occlusion accomplishes two things. First, it exerts pressure on the first batch of impression material, forcing it into all areas of exposed bone and natural co-abutments. Second, it records an impression of the opposing arch within the same unified mass of impression material.

After the materials have set, hold the buccal of the impression against the area of exposed bone, not against the opposing teeth, and have the patient open slowly in the path of least resistance.

This leaves the impression in the mouth, against the exposed bone and natural co-abutments, free of the opposing dentition.

Gently release the impression from the exposed bone. Ask the patient to stay relaxed and open.

As the impression starts to work free, the patient may help dislodge it from the oral cavity with his or her tongue.

The completed master impression is washed and inspected. The exposed bone, opposing arch, and natural co-abutments, all related in centric occlusion, have been recorded in one solid impression. Using a heavy-body rubber base impression material such as Permalastic (Kerr), the inferior buccal border of the mandible, mental foramen, and lingual fibers of the mylohyoid muscle are clearly visible (Fig. 14-30, A). Heavy-body rubber base impression material lacks the stiffness required to take a one-piece impression, and therefore requires the use of a custom tray and separate opposing arch and bite registrations. In a Citricon impression, the zygomatic border, junction of the hard palate and alveolar ridge, and opposing arch in the maxilla are clearly visible (Fig. 14-30, B). The impression is set aside.

Thorough Cleansing Before Closure

Suction, wash, suction again, and carefully inspect the impression site. Look at the deepest extent of the reflection, and examine the entire surface of bone. Remove any residual impression material. Particularly in the maxilla, check bone porosities for retained material.

Thorough inspection of the exposed bone and investing tissues is critical. No residual impression material may be left behind.

Release Flap Fixation

Using a suture or Noyes scissors, clip and remove each suture that holds the edges of the buccal and lingual flaps against the cheek. Inspect to ensure that no silk suture remnants are left behind. Coapt the flap edges together, and inspect to determine whether the trimming of the tissue edges performed earlier was adequate. If not, correct them now.

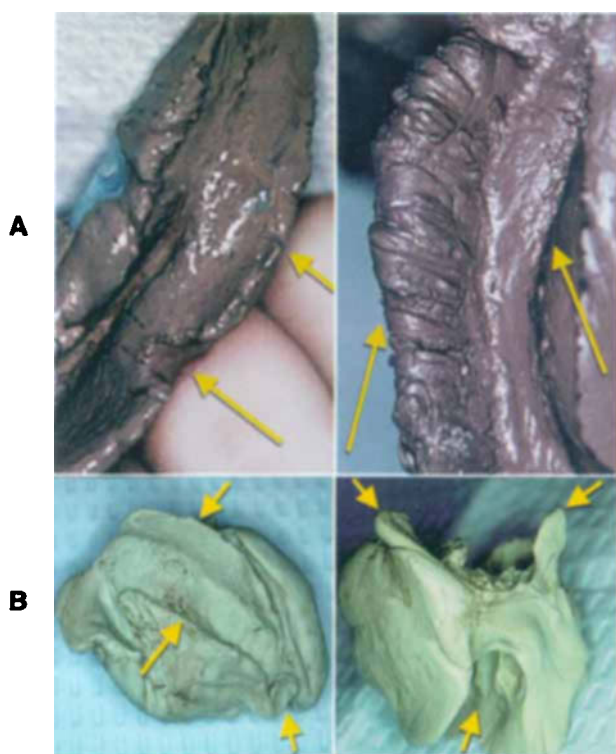


FIG. 14-30 ■ A, Rubber base impression showing turn of mandible and mental foramen (left) and mylohyoid muscle fibers and turn of mandible (right). B, Citricon impression showing inferior zygomatic border, junction of alveolar ridge and hard palate, and natural co-abutment (left), in centric occlusion (right).

Although these steps eventually become routine, they should not be taken for granted. Failure to meticulously check after every step of the procedure can lead to complications.

Stage One Final Closure—Suturing

Suture according to the principles and procedures described in Chapter 9.

After impressing for a subperiosteal implant, compress the flaps against bone with wet gauze to express all excess fluids from between the flap and the bone. This keeps the overlying tissues firm and free of unwanted bulk that could result if retained blood clots and turns into fibrous tissue during healing.

Provisional Prosthesis

Replace the provisional crowns over the premolar co-abutments. If the patient had a removable partial denture, reinsert it. It will serve as a stent to further compress and hold tissue in position.

The clinical portion of stage one is now complete.

Post-Stage One Home Care Instructions

As discussed in Chapter 9, advise the patient about the effects that can result from the trauma of the surgery, and prescribe prophylactic antibiotic and analgesic medications. Instruct the patient in proper maintenance of postoperative cleanliness and the need for a soft diet to ensure that the sutures are not disturbed, which could result in dehiscence.

VISIT 2: POST-STAGE ONE FOLLOW-UP AND SUTURE REMOVAL

The steps that are performed during the post-stage one follow-up visit are shown in Box 14-4.

General Evaluation

The patient is examined after 7 to 10 days. Patient progress and experiences are evaluated.

BOX 14-4 ■ VISIT 2, WEEK 1: SUTURE REMOVAL AND INTERIM EVALUATION

Conduct general evaluation
Remove sutures
Evaluate soft-tissue healing
Check and adjust co-abutment temporization as required

Generally, patients report little edema, with resolution before the follow-up visit. Hematomas are rare. Most often, little or no medication is needed for comfort. Be sure that the antibiotic regimen has been followed, the no-smoking rule observed, and a soft diet maintained.

Suture Removal

With rare exceptions, no dehiscence is observed. The soft tissues heal quickly. The sutured area is gently cleansed with water spray, and the sutures are removed carefully. No anesthetic is necessary. A Noyes or suture scissors that slips gently under a suture promotes comfort during this process. Apply tincture of benzoin to the area following suture removal.

If healing seems slow, one may remove alternating sutures and wait for another week to remove the rest. If healing is tenuous and tension seems to be the cause in an area, wait for another week to remove the sutures there.

Healing

Mucosal tissue heals rapidly in these cases. The chief cause of slow healing is smoking, and the second most common cause is excessive alcohol consumption.

Advise the patient in clear terms that the prognosis of any case may be seriously compromised if he or she cannot refrain from smoking or excessive alcohol consumption, at least throughout the course of treatment.

Case Sequencing—Scheduling Stage Two

The optimum sequencing for stage two, the implant insertion visit, is 2 to 4 weeks after stage one is completed. However, honoring this timeframe is not critical. Many unilateral subperiosteal implants are inserted 2, 3, or 4 months following stage one if such a delay is unavoidable.

During the interim, the patient is advised to eat and brush cautiously in the area of the implant site. The case sequencing for subperiosteal implants between stage one and stage two is not critical. In the interest of kindness, and because it is true, share this with the patient to alleviate anxiety.

SUBPERIOSTEAL IMPLANT DESIGN AND FABRICATION

Pour and Mount Master Models

The one-piece direct bone impression that captures opposing dentition and interocclusal registration in centric occlusion simplifies the design phase. After this impression is removed from the oral cavity, it is handled gently, with particular care not to touch or compress thin flanges. Cleanse the impression under cold water, gently blow it dry, and select an articulator for mounting.



FIG. 14-31 ■ Articulated models. Arrow indicates anterior tooth with marked long axis for parallelism guidance.

Quick-setting gray rock is a model material of choice. It sets quickly, like snow-white impression plaster, but is harder and retains dimensional stability. Do not box the impression, because doing so may distort the flanges. The impression is poured and mounted in four stages, with four separate small mixes of gray rock. First, make a small, loose mix and, holding the impression gently in hand with the bone surface facing up, gently tease a small amount of gray rock into place with a small spatula or brush. Be sure that the loose mix is against the entire bony surface to the height of the flanges. Because the mix is loose, doing so will not distort the flanges. Hold the impression until the first batch of gray rock initially sets. If the gray rock starts to set too soon, make another loose mix and continue filling the impression. After preliminary setting, turn the impression over and with another loose mix of gray rock, fill in the opposing dentition. Allow the mix to set in hand. Next, orient the impression within the articulator, and rehearse its placement. Adjust the articulator opening as desired. Pour another gray rock mix, and join the mandibular portion of the impression to the base of the articulator in the selected orientation. When this sets, the final gray rock mix is made, and the maxillary portion is joined to the articulator in its selected locked-in position.

Following hardening of the final gray rock mix, carefully open the articulator and tease the models from the elastic impression material. Some impression material may have to be scored and removed from undercuts. With all impression material removed, cleanse the models, blow dry, and close the articulator into centric occlusion. This bone impression is the master model for implant fabrication only. The centric occlusion recording is solely to determine optimal abutment location and height. If possible, the anterior natural co-abutment(s) was captured in the mold to aid in achieving abutment parallelism in the design phase (Fig. 14-31).

Design the Main Bearing and Connecting Struts

Mandibular Posterior Subperiosteal Implant. The practitioner should design the implant. First, pencil in the buccal main bearing strut. Place it on basal bone as close to the base of the mandible as possible. Distally stop at the



FIG. 14-32 ■ Arrows indicate position of buccal main bearing strut distal to mental foramen in mandible.



FIG. 14-33 ■ Arrow indicates position of lingual main bearing strut in area anterior and then superior to mylohyoid ridge in mandible.

point at which the ascending ramus rises from the residual alveolar ridge. In unilateral posterior mandibular cases, stop as anteriorly on the model as possible, but posterior to the mental foramen (Fig. 14-32). Next, pencil in the lingual main bearing strut. Anteriorly it extends against lingual basal bone, as far inferiorly as possible, alongside the roots of the premolar natural co-abutments. Try to place this strut slightly into an undercut area for additional primary retention of the implant. As it extends posteriorly, it is limited by the anterior border of the mylohyoid ridge, where it rises superior to the ridge and then passes over the alveolar ridge crest toward the buccal (Fig. 14-33). Connecting struts are now penciled in. The first to be designed is the one that will give rise to the abutment (Fig. 14-34). To determine the optimal location for the abutment, close the articulator to observe the location of the opposing dentition as a guide, and visualize the ideal position of the planned second molar in the final fixed bridge. This is the position at which the implant abutment should be located. Mark the corresponding location on the bone model. Also consider the bucco-lingual position of the abutment. Whereas in the case of endosteal implants the abutment must always arise at or near the ridge crest, this is not the case with subperiosteal implants. In most cases, one is able to position the abutment bucco-lingually to be centered under the occlusal surface of the planned restoration. Once the location of the abutment is marked, pencil



FIG. 14-34 ■ Arrows indicate position of connecting strut and abutment in mandible.

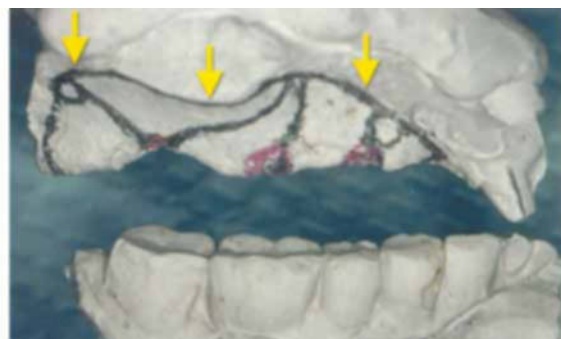


FIG. 14-36 ■ Arrows indicate position of buccal main bearing strut in maxilla.



FIG. 14-35 ■ Arrows indicate positions of connecting struts in mandible.



FIG. 14-37 ■ Arrows indicate position of lingual main bearing strut in area of junction of alveolar ridge and hard palate in maxilla.

in a connecting strut joining the mark to the buccal and to the lingual main bearing struts. Next, pencil in a connecting strut anteriorly that curves distally and passes over the ridge crest at least 3 mm from the distal natural co-abutment, to join the anterior extents of the buccal and lingual main bearing struts. The distal connecting strut may need special attention. As the distal extent of the lingual main bearing strut rises superiorly at the anterior border of the mylohyoid ridge and then crosses the ridge crest, the connecting strut attached to it may run distally in a hollow just buccal to the ridge crest where it joins the distal extent of the buccal main bearing strut. Auxiliary connecting struts may be added if required to ensure strength (Fig. 14-35).

Maxillary Posterior Unilateral Subperiosteal Implant. First, pencil in the buccal main bearing strut. Start anteriorly against basal bone, along the buccal surface of the natural co-abutments, as far superiorly as possible on the model. Proceed posteriorly to the anterior border of the zygomatic arch, inferiorly and then posteriorly against its inferior border, continuing superiorly behind its distal border and then posteriorly and inferiorly toward the area of the tuberosity (Fig. 14-36). Try to place the buccal and lingual main bearing struts into slight undercut areas to increase primary retention of the implant. Next, pencil in the lingual main bearing strut on basal bone starting anteriorly at the lingual surface along the natural co-abutments at the

junction of the hard palate and the alveolar ridge. Move distally toward the tuberosity, being careful to avoid impingement upon the area of the posterior palatine foramina (Fig. 14-37). Connecting struts are now penciled in. Again, the first to be designed gives rise to the pergingival strut and implant abutment. To determine the optimal location for the abutment, close the articulator to determine the position of the opposing dentition as a guide, and visualize the ideal location of the planned second molar overcasting on the final fixed bridge. This is where the implant abutment will be located. Mark the corresponding location on the model. Remember that the buccal plate of bone in the edentulous posterior maxilla most often reveals substantial resorption toward the lingual, to the extent that the ridge crest often is in cross-bite relative to the occlusal surfaces of the mandibular dentition. In such cases it is wise, when possible, to place the abutment toward the buccal to preclude or at least minimize the potential for cross-bite in the final restoration (Fig. 14-38). Once the position of a projected abutment is marked, pencil in a connecting strut from it to the buccal main bearing strut, and another to the lingual main bearing strut. If additional abutments are desired, they are penciled in at appropriate locations in the same manner. Next, connect the anterior extent of the buccal and lingual main bearing struts with a connecting strut that curves distally to pass over the ridge crest at least 3 mm from the distal of the dis-

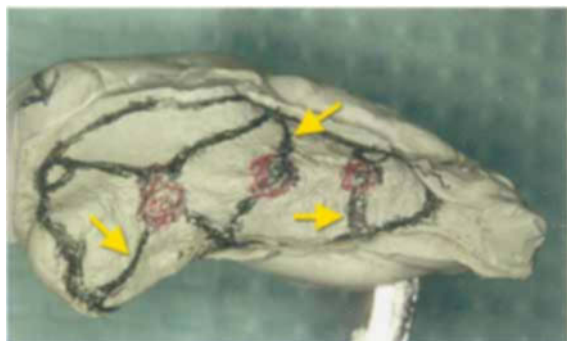


FIG. 14-38 ■ Arrows indicate position of connecting struts and abutment in maxilla.

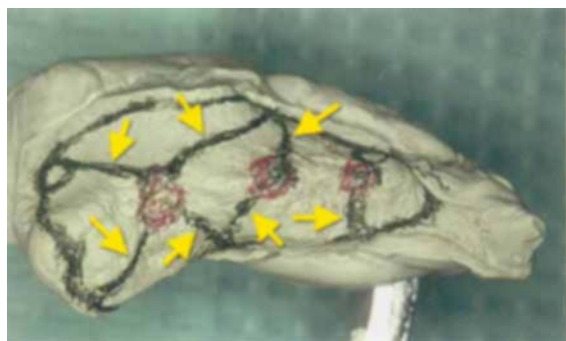


FIG. 14-39 ■ Arrows indicate positions of all connecting struts in maxilla.

tal natural co-abutment. The location of the distal connecting strut depends on the osseous anatomy. If there is a distal surface on the tuberosity, and in many resorbed cases there may not be, carry the distal connecting strut from the distal of the buccal main bearing strut, around the distal of the tuberosity, to join the distal of the lingual main bearing strut. If there is no distal to the tuberosity against which one can rest a connecting strut, cross over the ridge as distally as possible, running the strut along a hollow, depression, or over the most resorbed area of bone. Auxiliary connecting struts may be added if required to ensure strength and rigidity (Fig. 14-39).

Design the Abutment(s)

The optimal abutment design is discussed earlier in this chapter. Because the desired abutment configuration cannot be drawn on the implant model, it is important for the fabricating laboratory to have exact instructions regarding its fabrication. A sample drawing of the desired abutment configuration will suffice, with the caveat that at least 2 mm of interocclusal clearance is desired.

Position Initial Retention Screw Hole

A 3- to 4-mm screw fabricated of the same metal as the implant often is used to ensure initial stability during the



FIG. 14-40 ■ Screw hole (arrow) in mandible.



FIG. 14-41 ■ Screw holes (arrows) in maxilla.

early stages of healing. When periosteal integration is established, the screw no longer functions, but may remain in position. Only rarely is it removed.

Mandibular Posterior Unilateral Subperiosteal. In the mandible, position the screw along the buccal border, usually at the junction of the buccal main bearing strut and distal connecting strut (Fig. 14-40). The strut is widened in this area to accommodate the hole through which the screw will pass.

Maxillary Posterior Unilateral Subperiosteal. In the maxilla, position the screw hole in the buccal main bearing strut at the junction of the distal connecting strut, providing that this junction is at an area of solid bone distal to the sinus (Fig. 14-41). The strut is widened to accommodate the hole through which the screw will pass.

Laboratory Prescription

The laboratory should have instructions regarding the cross-sectional configuration and dimensions of the main

bearing and connecting struts. One need only instruct the laboratory to fabricate and finish a unilateral subperiosteal implant as designed on the articulated master model enclosed with the case, according to previously agreed upon instructions.

Laboratory Fabrication

This section outlines the basic procedure followed by the laboratory, to enable the practitioner to understand any questions or complications that may arise at the laboratory and provide appropriate input. After laboratory staff review the prescription for complete understanding, fabrication begins.

Investment Model. Subperiosteal implants are one-piece castings fabricated of various accepted biocompatible metal alloys. The process is similar to that used to fabricate removable partial denture frameworks. The master model is duplicated and poured in a unique casting investment material. This investment model is checked, trimmed, and cleansed.

Wax-Up. Using the penciled design on the master model as a guide, the implant is waxed up on the investment model. The configurations and dimensions required for the main bearing struts, connecting struts, and abutment are on file at the laboratory. In waxing up the abutment, the occluding articulated counter model is the guide for height. The guide for parallelism is the long axis of the prepared natural co-abutments on the master model. This step reconfirms the value of capturing these co-abutments at the impression stage. The completed wax-up is sprued liberally to ensure adequate metal flow to all areas of the implant.

Investment. The waxed-up sprued implant on the investment model is invested in a casting ring with the companion investment material, and allowed to set.

Casting. The first step is burn-out of the wax-up, just as in all lost-wax casting techniques. The implant must be cast in a biocompatible material, usually a cobalt-chromium-molybdenum alloy such as surgical Vitallium. Following burn-out, casting begins. There are several sophisticated casting techniques, each requiring specific timing and heat level sequences and usually performed in a vacuum or an inert gas such as argon.

Finishing Process. Following casting, the investment material is removed from around the implant casting. The casting is cleansed, and its sprues and buttons are cut away. Flash, if any, is removed. The finished casting usually is given a sand-blasted surface. A consensus conference conducted by 10 practitioners with long experience in subperiosteal implant dentistry concluded that evidence is lacking that coatings contribute to the safety, efficacy, or longevity of subperiosteal implants, although a coating may be used if desired.¹⁷

Passivation. The passivation procedure, unique to the formula of any biocompatible metal, oxidizes the surface of the implant. The laboratory follows the appropriate protocol. Following passivation, the implant is cleansed and

BOX 14-5 ■ VISIT 3, WEEK 2: STAGE TWO IMPLANT PLACEMENT

Confirm use of prophylactic antibiotic
Set up instrumentation
Administer anesthetic
Make incision
Reflect tissue
Seat implant
Check abutment for prosthodontic parallelism and interocclusal clearance
Adjust and reseat implant, if required
Set retaining screw(s)
Perform soft-tissue treatment
Suture
Check temporization of premolar co-abutments
Temporize provisional implant abutments, if required
Provide home care instruction
Schedule follow-up visit

packaged. A prefabricated initial retention set-screw of compatible metal is included.

Materials and Biocompatibility. Subperiosteal implants tend to be cast in surgical Vitallium. This material is biocompatible and is available in many variations around the world.

Implant Sterilization

When received from the laboratory, the implant and its initial retention set screw(s) are pouched, sterilized, and set aside with the stage two armamentarium. Sterilization is accomplished in the conventional manner. Guidelines for gravity air displacement steam sterilization are for an exposure time of 30 minutes at 250° F (121° C) or 15 minutes at 270° F (132° C). For prevacuum steam sterilization, an exposure time of 4 minutes is required at 270° F (132° C). The sterilized implant in its pouch is transferred to the stage two implant insertion surgical tray setup. These implants may be cleansed and resterilized as required.

VISIT 3, WEEK 2: STAGE TWO IMPLANT PLACEMENT

The steps that are performed during the stage two implant placement visit are shown in Box 14-5.

Confirm That Preoperative Medication Has Been Taken

The preoperative prophylactic antibiotic should have been taken as prescribed. Confirm this when the patient arrives for treatment. If it has not been taken, administer it preoperatively.

■ Instrumentation Setup—

The Armamentarium

The sterilized instrument setup is placed in the treatment area. It contains all the instruments required for the stage one procedure, as well as a tissue punch to help contour tissue around abutments before final closure, a screwdriver of compatible metal to set the initial retention screw following implant insertion, and an XL high-speed bone bur to create a pilot hole for the retention screw.

Preoperative Tissue Preparation

Again, as in stage one, a bactericidal solution such as povidone-iodine (Betadine) is applied to the operating field and its surrounding tissues. Professional prophylaxis should be performed before the procedure. Before applying povidone-iodine, remove any debris that may be present.

Local Anesthetic, Promotion of Comfort, and Control of Bleeding

The local anesthetic regimen for stage one surgery is followed again.

Incision

Remove the partial denture, if there is one, and the provisional prosthesis over the prepared natural co-abutments. The incision is made along the same incision line made for stage one, to the same extent mesially and distally.

The tissues coapted at stage one usually are not yet fully healed. Therefore, an incision line parallel to but not through the original incision line would require that the fragile healing line be reflected with one of the new flaps. The healing tissue along the original incision line may tear away because it is still weak. This complication to suturing and healing can be avoided by incising along the original incision line. Healing after the second incision is uneventful.

Tissue Reflection

Tissue reflection is accomplished exactly as for stage one, and to the same extent.

However, reflection is accomplished in stage two with greater ease and less bleeding. The tissue reflected at stage one is not yet fully reattached to the underlying bone. It lifts away with ease. Remember to keep one's eyes on the juncture at which the periosteum is lifting from bone to be sure to stay under it. Confirm that the tissue is reflected as far as it was in stage one.

Trim Tissue Flap Edges

The edges of the tissue flaps are carefully inspected and trimmed with a serrated edge tissue scissors in the same way as described for stage one.

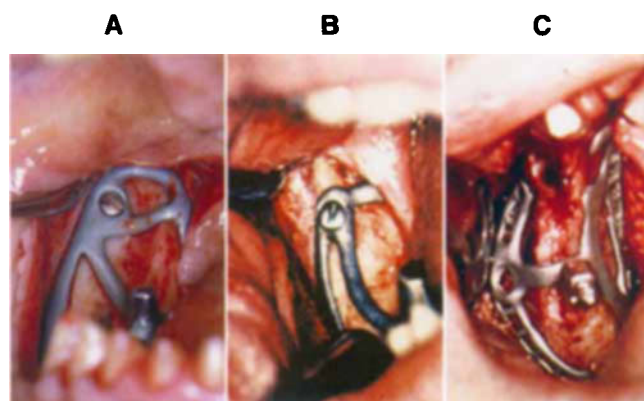


FIG. 14-42 ■ Seating of mandibular (A, B) and maxillary (C) unilateral subperiosteal implants.

Because of the greater ease of tissue reflection, less trimming is required at this stage.

Trial Seat the Implant—Check Fit to Osseous Contours

There is no need to affix the reflected tissue flaps to the cheek or across the arch to maintain access to the exposed area, as was done for impressing in stage one. The implant is removed from its sterilization pouch for trial seating. The tissue flaps are held away with a periosteal elevator or tissue forceps. The implant is gently seated on the exposed bone (Fig. 14-42).

This procedure is much the same as fitting the framework of a removable partial denture over clasped teeth. One varies the angles of approach, and by trial and error, the path of insertion that permits greatest ease of seating is determined. If the implant seats fully on the supporting bone, the trial seating is successful, the implant remains in place, and the procedure continues.

In the rare instance in which an implant cannot fully seat because of a protuberance of bone near an undercut area, even after trying various paths of insertion, place an orangewood stick against the occlusal surface of the abutment and try tapping it into position with a mallet. Most often, this will solve the problem. If not, reduce the protuberance. Remove and rinse the implant and set it aside on the sterile tray. With a bone file or rongeur, remove the smallest amount of bone that will allow full seating of the implant. Repetition of this procedure may be required.

This removal of bone does not compromise the case. No main bearing or connecting strut will rest against the reduced bone, because the implant moves past the protuberance to its final position to achieve full seating.

Check Abutment(s) for Prosthodontic Parallelism and Interocclusal Clearance

Confirm that the abutment on the seated implant is in parallelism with the prepared natural co-abutments. Also confirm that adequate interocclusal clearance is present when the patient closes into centric occlusion.

These conditions are almost always correct if the implant was designed properly and laboratory instructions were followed.

If lack of parallelism or interocclusal clearance is apparent at this time, note what adjustments are required. Remove the implant, rinse, and with sterile heatless wheels or stones, followed by a rubber polishing wheel, make the adjustments. The implant is cleansed, reinserted, and rechecked.

This procedure may need to be repeated until acceptable parallelism and clearance are achieved. Be aware that this process is almost never needed when the laboratory follows its instructions correctly.

Final Seating of the Implant—Set Initial Retention Screws

With the implant firmly seated against the supporting bone and held immobile with pressure applied to the abutment, the tissue is reflected to expose the screw hole. With an XL bone bur in a high-speed contra angle with coolant, a pilot hole is made through the screw hole to a depth of approximately 1.5 to 2 mm.

Do not make the hole too deep or wide, to preserve the initial retentiveness of the set screw.

Place and turn the initial retention set screw clockwise with a screwdriver until it is fully seated and tight against the implant framework. Final seating is complete (Fig. 14-43).

Gingival Flap Plastic Surgery

If required because of the presence of flabby tissue over the incision site preoperatively or in the case of excessively thick maxillary gingiva, remove any excess tissue that will interfere with coapting the flaps, decrease flap thickness if required, and reduce flabby tissue according to the procedures and principles described in Chapter 9.

Whether or not these plastic surgery procedures are required, tissue punch to remove any tissue that bunches around the pergingival strut upon final coapting, again according to the procedures described in Chapter 9. When the soft tissue is ready for suturing, take a periapical radiograph for the patient record. For an implant with one abutment, place the first suture just mesial to it. Penetrate first on the buccal flap even with the mesial border of the



FIG. 14-43 ■ Placement of a set screw with compatible driver.

abutment, and pass the needle through the lingual flap at the mid-point of the abutment. Penetrate next on the buccal flap even with the distal border of the abutment and pass the needle through the lingual flap at the mid-point of the abutment, and tie.

In the case of a double-abutment implant, the first suture is placed at the mesial of the mesial abutment, the second at the distal of the distal abutment, the third at the distal of the mesial abutment, and the fourth at the mesial of the distal abutment.

The next suture is placed carefully to secure closure of the gingival flap against the distal of the nearest natural co-abutment, followed by a suture 2 mm mesial to the distal extent of the gingival flaps.

These sutures secure the reflected flaps at the mesial and distal borders of the abutments, and provide important flap orientation to guide placement of the remainder of the required sutures.

Now, spacing sutures 2 to 3 mm apart, fill in all unsutured areas carefully. Compress the flaps against the underlying bone with wet gauze, and inspect. Add sutures if required.

Always, with each suture, secure a good bite of tissue, preferably within the band of attached gingiva. Successful suturing is an important aspect of implant insertion. Securely sutured flaps heal rapidly by primary intention, with reduced edema.

Check Temporization of Premolar Co-Abutments

Reseat the premolar provisional crowns and recheck margins, embrasures, and occlusion. Again check for adequate clearance of the implant abutment(s). Adjust intraorally if required.

The provisional crowns over the natural co-abutments were removed before implant insertion to provide clear observation and access to the field of operation.

In checking the marginal fit, pay attention to the distal of the nearest natural co-abutment, particularly where the incision passed through the distal of its gingival cuff.

Provisional Implant Temporization

In Nonesthetic Areas. Posteriorly, in nonesthetic areas, no provisional teeth are placed.

In mainstream posterior unilateral subperiosteal treatment, provisional restorations are placed only if required for esthetics. The implant is initially held immobile by the set screw, and in many cases by additional frictional fit if the implant seats into an undercut area. The abutments are out of occlusion. The implant is in a state of hypofunction, in which only cheek and tongue movement or a stray bolus of soft food can apply load. This hypofunctional state enhances periosteal integration through the formation of an enveloping collagenous connective tissue sheath that is part of the periosteum and is attached to bone through Sharpey's fibers.

In Esthetic Areas. In the posterior, provisional teeth are placed only in esthetic areas. These are splinted to the existing provisionals on the natural co-abutments. Provisional prostheses are conventionally fabricated as if for a fixed bridge supported exclusively by natural abutments. The occlusal surfaces are kept narrow and just out of occlusion.

The natural co-abutments ensure implant immobilization. The portion of the restoration over the implant and pontic is kept just out of occlusion, and the need to maintain a soft diet is emphasized. The most carefully made provisional prosthesis can be weak, break, or have delicate margins. Any one of these may interfere with healing. When esthetics is not a consideration, only the natural co-abutments are temporized.

The provisional prosthesis is placed with sedative cement applied only to the natural co-abutment crowns. No cement is placed around the implant abutment. Frictional fit is adequate.

This procedure protects the implant from being disturbed during healing, or when the provisional prosthesis is removed to facilitate suture removal or the fabrication of the final prosthesis.

Radiographic Record

A panoramic or series of two or three periapical radiographs is taken of the area with the seated implant (Figs. 14-44 and 14-45).



FIG. 14-44 ■ Mandibular postoperative radiograph.



FIG. 14-45 ■ Maxillary postoperative radiograph.

BOX 14-6 ■ VISIT 4, WEEK 3: SUTURE REMOVAL AND INTERIM EVALUATION

Conduct general evaluation
Remove sutures
Evaluate soft-tissue healing
Check and adjust co-abutment and implant temporization as required

The radiographs are taken to complete the patient record. They are not obtained to check full seating of the implant. The best check for correct seating is direct observation before closure. The vagaries of radiography should not undermine confidence in one's direct observation.

Immediate Post-Stage Two Home Care Instructions

The considerations at this time are identical to those after stage one surgery.

VISIT 4: POST-STAGE TWO FOLLOW-UP VISIT, SUTURE REMOVAL

The steps that are performed during the stage two implant placement follow-up visit are listed in Box 14-6.

General Evaluation

This follow-up visit is scheduled 7 to 10 days after insertion. Earlier visits are generally not required. Evaluate the progress and experiences of the patient.

Patients generally report minimal edema that has already resolved. Hematoma rarely is reported, and most often the pain medication was not used. Always confirm that the antibiotic regimen was followed, that the no-smoking rule was observed, and that diet was appropriate.

Suture Removal

If required, gently remove the provisional prosthesis for better access to facilitate suture removal. Often it can be left in place. Use a Noyes or suture scissors and fine forceps. The scissors slip under and sever each suture with little trauma to the underlying tissue. Apply a medicament such as tincture of benzoin. No anesthetic is necessary.

Suture removal should cause little or no discomfort. Discomfort only occurs when a forceps is used to pull the suture up to sever it. Using a suture or Noyes scissors obviates this.

Healing

Check that soft-tissue healing is by primary intention. Observe the pergingival cuff around the nearest natural co-abutment and the healing around the implant abutments, and medicate if necessary.

Problems with soft-tissue healing rarely are observed at this time.

Check Provisional Restoration

Before replacing the provisional restoration if it was removed for suture removal, examine for gingival signs of overextended margins or pontic, and adjust accordingly. Recheck the occlusion, and adjust if necessary.

These details are important. Anything that promotes gingival health is worth doing. Ideal case sequencing always can be followed if every step of the procedure is performed carefully, and then checked and adjusted as required.

Post-Stage Two General Considerations

In cases of normal healing, to follow ideal case sequencing, make the next appointment 7 to 10 days following suture removal.

BOX 14-7 ■ VISIT 5, WEEK 4: MASTER IMPRESSION AND INTERARCH OCCLUSAL REGISTRATION FOR PROSTHESIS FABRICATION

Expose natural co-abutments
Take master impression
Perform interarch occlusal registration
Select shade

This time span allows sufficient healing of the overlying soft tissues and around the incised gingival cuff of the natural co-abutment before the first appointment to fabricate the final prosthesis. Almost always, the site is ready for final impressioning 1 week after suture removal.

VISIT 5: MASTER IMPRESSIONING AND INTERARCH OCCLUSAL REGISTRATION FOR PROSTHODONTIC RESTORATION

The steps that are performed during the master impressioning and interarch occlusal registration for prosthodontic restoration visit are shown in Box 14-7.

General Considerations

The prosthodontic restoration of mainstream unilateral subperiosteal implant cases is essentially the same as that of conventional nonimplant cases. Simply fabricate the required three- to five-unit fixed prosthesis as one would for a fixed bridge supported entirely by natural abutments. Remember that although it is perceived that implant dentistry prosthodontics are complicated, this is not true for all modalities. For subperiosteal restorative dentistry, one need not take special courses or use special laboratories or an array of specialized components.

Although the restorative regimen is conventional, there is an ideal time sequencing that should be followed insofar as possible. This sequencing is not as critical as that for the endosteal implant modalities, but following it promotes successful case completion with the best possible prognosis. It is important to understand how the healing cycle works, and its timing, to fully understand why the schedule of restoration described hereafter is considered ideal. Reserve 2 to 4 weeks for complete fabrication of the final prosthesis.

Master Impressioning/Master Model

Taking the master impressions and pouring master models is best accomplished using one's conventional technique of choice for tooth-supported fixed bridges. Retraction cord usually is placed to promote hemostasis and provide

BOX 14-8 ■ VISITS 6 TO 7, WEEKS 5 TO 7: FABRICATION, TRY-IN, AND ADJUSTMENT OF FINAL PROSTHESIS

Try in bisque-baked bridge directly, or try in copings and/or assembled framework before bisque-bake try-in
Check occlusion, tooth contours, embrasures, and margins, and reconfirm shade

space for one's elastic impression material of preference. Carefully inspect the site for any residual material after the impression is removed, and cleanse as necessary.

Recording Jaw Relationships

Again, one's preferred technique for recording jaw relationships in the fabrication of a conventional prosthesis should be used.

VISITS 6 TO 7: TRY-IN AND ADJUSTMENT OF FINAL PROSTHESIS

The steps that are performed during the visits for try-in and adjustment of the final prosthesis are shown in Box 14-8.

Timing of Prosthesis Fabrication

One's customary sequencing of prosthesis fabrication should be followed. Remember that ideally, the final prosthesis should be fixed 2 to 4 weeks following master impressioning and bite registration. Many practitioners write their laboratory prescription for a return of an assembled bisque-baked prosthesis try-in, while others try a one-piece frame casting first, and then bisque bake. Another option is to try in individual copings, assemble them, and then bisque bake and go to completion. Each of these methods requires a different number of patient visits. As long as the 2 to 4 weeks completion time is honored, any of these methods can be successfully used.

Implant-Related Prosthodontic Considerations

Central Fossae/Ridge Crest Relationships. When teeth are removed or lost, resorption occurs at the expense of the buccal and labial plates of bone. Thus, ridges resorb medially, toward the lingual, as they lose height. The resorbed ridge crest is lingual to the location of the original, unresorbed ridge crest when teeth were present. Thus, the abutment of the subperiosteal implant often is placed as far buccal to the resorbed ridge crest as possible, but in most cases will remain lingual to the position of the teeth when they were present.

In positioning replacement teeth, the central fossae generally should replicate those of the original teeth to help ensure ideal occlusion, esthetics, and the dimensional and

functional integrity of the vestibule. Therefore, the replacement teeth will be positioned partially buccal to the healed ridge crest, and the implant abutment will project under the lingual portion of the overlying crown. In the maxilla it sometimes is necessary to establish an edge-to-edge occlusion, or even a cross-bite. In the mandible, occlusion may be established primarily between the tip and buccal incline of the maxillary lingual cusp and the central fossa and lingual incline of an extremely narrowed mandibular buccal cusp. Because of resorption patterns, it may be necessary for proper function and esthetics to ridge lap the buccal border of the implant abutment crown, especially in esthetic areas.

Ridge Lapping Implant Abutments. In conventional fixed bridges, the ridge lap is important. To provide an esthetic lineup of pontics in the area of the gingival margin, a passively placed ridge lap is formed labial or buccal to the ridge crest. These pontics are fabricated to provide esthetic gingival curvature, and thus appear to be growing out of the gingiva. In conventional fixed prostheses, this cannot be successfully accomplished with crowns over natural teeth. The gingival sulcus of the tooth becomes periodontally involved, no matter how diligently home care is performed.

However, ridge lapping is an important, predictable, and effective option for subperiosteal implant abutments with attached gingiva at the buccal or labial border. Although there is a peri-implant gingival sulcus with hemidesmosomes, there is no direct fiber insertion into the implant.⁴ Nonetheless, in mainstream cases, the abutment margins are almost always in attached gingiva. This is why ridge lapping in these cases succeeds. For more than 30 years, subperiosteal implant prostheses have successfully functioned with ridge-lapped implant abutments. The esthetic result and ease of cleansability are materially enhanced when this restorative option is chosen.

In forming a ridge lap, note that all proximal and lingual implant abutment casting margins are created as they would be against natural teeth. Only the buccal areas are extended. This is best accomplished in the laboratory by esthetically positioning replacement teeth over the implant abutments as though they were pontics. The implant abutments are positioned within the casting, governed by the dictates of esthetic contouring of the ridge lap. It is desirable that the implant abutments rise through the gingiva at a central point under the overlying crown, but it is neither hygienically nor esthetically essential that they do so. In the area of the ridge lap, place the metal casting margin at or slightly above the gingiva and extend metal 2 mm shy of the expected contour to allow ample room to adjust the resin or porcelain ridge lap for esthetics at try-in without exposing metal in the process.

In nonesthetic areas, ridge lapping is optional. Bullet-shaped crowns with wide embrasures may be used, depending on practitioner preference and patient acceptance.

Finishing Lines Against Abutments/Embrasures.

In the area of the ridge lap, the finishing line of the crown is placed at or up to 1 mm above the gingival margin, to allow for proper flossing and flow of fluids during lavage.

BOX 14-9 ■ VISITS 8 TO 9, WEEKS 8 TO 9: CEMENTATION OF FINAL PROSTHESIS

Remove provisional restoration
Try in completed prosthesis
Check previous adjustments and shade
Perform provisional cementation
Evaluate patient comfort and gingival adaptation to pontic and crowns
Perform final cementation

All margins are placed above, at, or below the free gingival crest, in accordance with one's preference when working with crowns over natural abutments.

Occlusion. Occlusion is also established in accordance with the techniques and principles with which one is most familiar and comfortable when fabricating a conventional fixed prosthesis. Narrow bucco-lingual dimensions, anatomic or semi-anatomic noninterfering cuspid relations, group function, cuspid protection, long centric, gnathologic principles, and other concepts of occlusion are all successfully used with subperiosteal implants.⁷

Restorative Materials. Most conventional materials can be used, such as porcelain-to-metal prostheses, gold occlusals with acrylic veneers, and gold superstructures with acrylic teeth. Gold and acrylic occlusal surfaces transmit less force through the implant into the investing tissues than porcelain. Use of an alternative restoration material is not required in mainstream cases but may be of some advantage in cases offering a more marginal prognosis.

VISITS 8 TO 9: CEMENTATION OF FINAL PROSTHESIS

The steps that are performed at the visits related to cementation of the final prosthesis are shown in Box 14-9.

Provisional Placement

The final restoration may be placed provisionally for up to 1 week. Provisional cement is not applied to the implant abutment. Provisional cement is conventionally applied to the natural co-abutment only.

Final Placement

The final restoration is seated with one's crown and bridge cement of preference. Zinc oxyphosphate, polycarbonate, and acrylic cements are all successfully used.

Postoperative Radiographic Record

A postoperative radiographic record is obtained. A panoramic radiograph and/or two or three periapical radiographs are sufficient for this purpose.

AFTERCARE AND MAINTENANCE Regimen for Slowly Increasing Function

The tissues investing subperiosteal implants are essentially collagenous. The main bearing struts on the day of implant insertion are between the inner layer of the periosteum and the underlying cortical bone. During the healing cycle, they become enveloped in fibrous tissue constituting the outer layer of the periosteum. The time required for healing before full function can be resumed is shorter than that associated with endosteal implants. With no adverse effects on the healing or prognosis, full function may be resumed in 4 to 5 weeks. Until that time, the implant, because of the 2- to 4-week requirement for final prosthesis fabrication, is in hypofunction.

As discussed in Chapter 9, professional and home maintenance must be performed regularly and diligently to avoid complications.

COMPLICATING AND ATYPICAL CONDITIONS

Common Complicating and Atypical Conditions

Many of the complicating and atypical conditions that are common to the mainstream treatment procedures using the abutment-providing implant modalities, as discussed in Chapter 9, are applicable here. These include minimal width of attached gingiva, frayed or torn flaps, excessive bleeding, retained root tip, presence of a cyst or granulomatous tissue, friable tissue at suturing, excessive postoperative edema, and retained impression material. Each of these conditions is rare. Handling such complications properly is covered in Chapter 9.

Areas of Excessive Ridge Height

Occasionally, one encounters limited areas of overabundant bone for the placement of a subperiosteal implant. These limited areas deserve special consideration. First, while mentally designing the implant as the tissue is reflected, determine whether a connecting strut should be placed across an area of excessive ridge height (Fig. 14-46). If so, reduce that height at the time of ridge crest cleaning and alteration either by cutting a groove into the ridge toward basal bone, or removing the entire area of excessive ridge. Whereas endosteal implants place residual alveolar ridges back into function and thereby preserve them, subperiosteal implants do not. Overabundant ridges therefore will resorb over time. If a connecting strut passes over such an area, it will in time work its way through the gingiva and dehiscence into the oral cavity. Removing this excess bone in advance and seating the connecting strut on basal bone avoids this problem. Excess bone may need to be removed, even if a crossover strut need not be passed over it, when there is insufficient interocclusal clearance over it. Reduction can help make the final prosthesis more esthetic and cleansable.

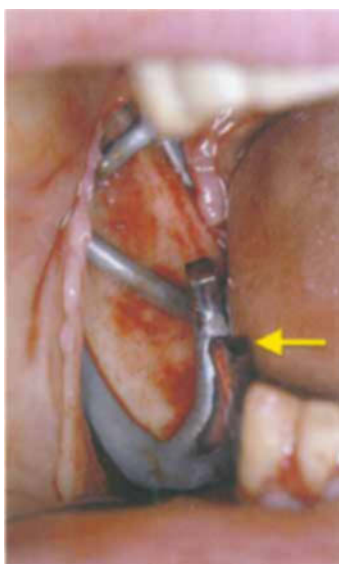


FIG. 14-46 ■ Arrow indicates position of incorrect placement of connecting struts on alveolar ridge of excessive height.

Knife-Edge Ridge Areas

Knife-edge ridge areas are always removed, where and whenever observed. If left in place, the overlying healed tissue is tender to compression. The knife-edge bone ridges resorb and alter the fit of the overlying prosthesis. These areas are easy to reduce. Finish the process with gentle smoothing using a bone file or sharp curette.

Inadequate Soft-Tissue Closure—Dehiscence

Dehiscence is not always the result of inadequate suturing. The patient may traumatically separate the tissues. Whatever the etiology, anesthetize, debride the edges of tissue, suture deeply, and repeat important home care instructions. When suturing will not suffice, any periodontal pack may be applied over the exposed area, and healing, though retarded, will progress. This delays the recommended case sequencing.

Inadequate Impression

The master impression is cleansed and inspected following removal during the stage one procedure. Consider the final implant design and relate it to one's ability to identify on the impression sufficient anatomy to support each planned strut. If the impression is adequate, pour the model. If not, identify the cause of the inadequacy. First, reexamine the patient to be sure that in fact adequate tissue reflection was performed. If the reflection was inadequate, or if the impression material failed to reach all exposed areas, retake the master impression, remove it, and confirm the corrections.

In some cases, what seemed adequate at the time seems questionable when examining the master model. By this time the patient is sutured and on the way home. Be sure

that as much exposed bone as possible is used for appropriate support. Almost always, this will suffice, because the model typically has much more exposure than the required minimum.

Incomplete Final Seating of Implant

Depending on the degree, incomplete final seating of the implant may or may not be a complication. If portions of the implant do not fully seat, even after protuberances or bulges are removed, and if under a small area of one or two struts there is a lack of contact with bone, there is little reason for concern. The area will heal with dense, fibrous connective tissue. A small amount of **nonresorbable** alloplastic bone augmentation material may be used in such cases.

If major portions of the implant do not fully seat, the master impression must be retaken and the implant refabricated. This rarely occurs in mainstream cases.

Inadequate Retention of Seated Implant

Inadequate retention of a seated implant is caused by insufficient anatomic undercut areas and/or small-sized implants. A retention screw solves the problem. Keep the initial pilot hole for the set screw narrow to ensure adequate grip for the set screw threads in the bone. When tightening set screws, be sure not to strip the bone threading, which can compromise early retention.

Home care instruction is important. The implant remains in as little function as possible.

VARIATIONS AND ALTERNATIVES

Various Abutment Connections

In the case of mainstream unilateral subperiosteal implants, the abutment design replicates that of the plate/blade form.

Total and circumferential subperiosteal implant cases are not considered mainstream. Their overlying prostheses may be fixed or removable. If a removable overdenture is placed on the implant, various ball, O-ring, and clip and bar attachments and assemblies can be used.

Restorative Procedure Options

Two unilateral subperiosteal implants can be used for bilateral distal support of a complete arch fixed bridge. The stage one implant procedure is identical to the mainstream procedures already discussed. Only the overlying prosthesis is different in that it includes more teeth, up to the entire arch.

Precision and Semi-Precision Attachments

The use of precision and semi-precision attachments sometimes is considered to facilitate the fabrication of a new prosthesis should the implant fail. However, the long-term survival of these implants is commonly up to 15 years

or longer. Should an implant fail, the prosthesis is separated at the distal of the pontic closest to the natural co-abutment. The implant is removed, and following healing a new one is fabricated and seated. Restoration follows with the fabrication of a two-unit restoration supported by the new implant and an overcasting on the pontic of the original bridge.

Stress-Breaking

The use of stress-breaking components in mainstream unilateral subperiosteal prostheses may be counterproductive. One objective of the final prosthesis is to provide rigidity, especially during the healing phase, and shared loading in function. Posteriorly, functional load is up to four times greater than anteriorly. In posterior mainstream cases, the implant is almost always posterior to the natural co-abutments. The stress breaker protects the natural co-abutments more than the implant, which is subjected to added load. A rigid prosthesis offers the best prognosis.

Coatings

A consensus conference of 10 practitioners with long experience in subperiosteal implant dentistry concluded that evidence is lacking to confirm that coatings are of benefit. Complications such as coatings that crack, delaminate, dissolve, or may act as pathways for infection are observed. Coated implants cannot be handled easily, resterilized, or cleansed. They may complicate the procedure, with no confirmed benefit.

Various Strut Dimensions and Designs

The strut dimensions discussed in the teaching case are recommended. Variations in width, height, and cross-sectional dimensions sometimes are observed. No research exists to establish benefit of one set of dimensions over another. Some practitioners design certain main bearing struts with fenestrations to enhance fibrous tissue envelopment of the implant (Fig. 14-47).

Various Basic Designs

In all areas of technology, new designs, protocols, and materials always are being developed.^{18,19} Although innovations are attractive, clinical use is what counts. Only long-term clinical trials and general use can determine the value of a new design. The basic mainstream posterior unilateral subperiosteal designs taught in this chapter have been used for many years and are known to work. In the maxilla, some alternative designs offer more lingual support and fewer labial struts. In the mandible, struts are sometimes extended onto the lateral border of the ascending ramus. The long-term benefits of such variations in design weighed against long-term complications are as yet unknown.

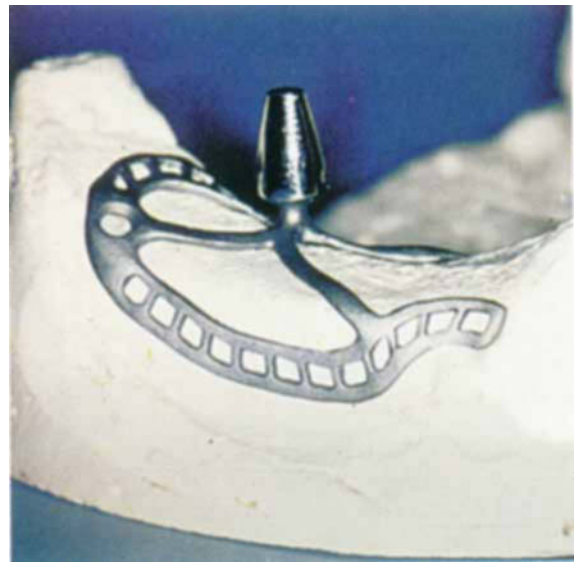


FIG. 14-47 ■ Fenestrated main bearing struts.

Implant Insertion Over New or Partially Healed Extraction Sites

Implant insertion over new or partially healed extraction sites is not mainstream subperiosteal implant dentistry. It is better to be patient and wait for complete healing before seating a subperiosteal implant. Additional resorption that may occur at the extraction site is not a concern, and in some subperiosteal cases can be considered a benefit.

CAD-CAM Design of Subperiosteal Implants

Computer-assisted design–computer-assisted manufacture (CAD-CAM) design of subperiosteal implants is not considered a mainstream procedure because of technique-sensitivity and cost, and because CAD-CAM generated models may not be as accurate as direct bone impressions.²⁰ In the hands of highly trained technicians and practitioners, accurate models can be predictably fabricated, but direct bone impressing is more predictable in mainstream cases.

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15 Bone Enhancement

Increasing the Volume of Available Bone

A basic premise of this book is that one's first few implant cases should involve mainstream treatment. By definition, in mainstream cases available bone is sufficient for the implant modality to be used. No bone enhancement is required. Therefore, the entry-level applications of bone enhancement procedures are supplemental to mainstream implant dentistry. Bone enhancement procedures show promise and can be useful. Because the understanding and practice of bone enhancement is rapidly growing and evolving, it is recommended that one thoroughly understand its principles and clinical applications. The importance of this adjunctive discipline will continue to increase over time. As one progresses toward the treatment of intermediate and advanced implant dentistry cases, one can help more and more patients through the judicious use of bone enhancement procedures.

This chapter examines the current scientific understanding of bone enhancement, and certain clinical applications that may be used to treat atypical conditions or complications that are sometimes encountered in mainstream implant dentistry cases.

STATE OF THE ART OF BONE ENHANCEMENT

Bone enhancement is a rapidly developing area of treatment. Little consensus exists regarding many aspects of its underlying science and clinical application.¹⁻⁴ A literature review reveals inconsistent and sometimes contradictory use of vocabulary. Industry has complicated this situation by coining words with implications that can be contrary to the understanding of scientists in the field. Therefore, much of this chapter is devoted to terminology and appropriate definitions, as the scientific community understands them.

In addition, there is a diversity of opinion regarding what materials should be employed for typical clinical applications, the rationale for their use, the rationale for using combinations of materials,⁵ the percentages of each material used in combination,⁶ and how these percentages are best determined. Therefore, following a review of terms, this chapter highlights specific clinical applications of bone enhancement that are useful to supplement main-

stream implant dentistry, and identifies specific materials with known safety and effectiveness for use in such cases.

BONE GRAFTING/AUGMENTATION Vocabulary and General Considerations

Bone grafting/augmentation materials can be separated into four broad categories, as shown in Box 15-1.

Classification of Grafting Materials

Autogenous. Also autograft, autochthonous, or **autologous graft**. Autogenous **grafting material** is **harvested** from one or more donor sites within the same individual.

Allogenic. Also **allograft** or **homograft**. **Allogenic grafting material** is harvested from the same species as the recipient, but is of a different genotype. It is a graft taken from one human and transplanted into another.

Xenogenic. Also **xenograft**, **heterograft**, or **heterologous graft**. **Xenogenic grafting material** is harvested from a species different from that of the recipient.

Alloplastic. Also **alloplast**. **Alloplastic grafting material** is synthetic or chemically derived from a nonliving source, and is inert.

Nature of Grafting Materials

Autogenous. The consistency of the **autogenous grafting material** required for a specific treatment is dictated by the character and volume of bone required to correct or enhance the host site, as well as the location of the donor site and the method of harvesting. Small amounts of cancellous bone are best harvested from osteotomy twist drill shavings or sterile suction slur filtration products.^{7,8} Greater amounts of cancellous bone are easily harvested distal to the last maxillary molar, and from the tuberosity.⁹ Should cortical bone also be desired, the ascending ramus and symphysis of the mandible can contribute what is required. Larger amounts of autogenous bone are commonly taken from the iliac crest, ribs, and certain long bones.¹⁰ Substantial cortical grafts can be harvested from the occipital area of the cranium.

The consistency of the harvested autogenous grafting material is variable. It may be a viscous slur, or a plastic mass of cancellous bone, often in combination with cortical bone. It can also take the form of essentially cortical blocks, which can be harvested in different volumes and

BOX 15-1 ■ CLASSIFICATION OF BONE GRAFTING MATERIALS

Autogenous: harvested from a donor site within the same individual

Allogenic: harvested from a different member of the same species

Xenogenic: harvested from a different species

Alloplastic: synthetic or chemically derived from a nonliving source

shapes and carved to nest within or against a host site as accurately as possible.

Harvested autogenous material is best used fresh and as quickly as possible. It may also be frozen or stored in isotonic saline for future use. Because cells lyse, autogenous material should not be stored soaked in blood.¹¹

Allogenic. The consistency of allogenic grafting material required for a specific treatment depends on first determining the character and volume of bone required at the host site. If autogenous material is used as the primary graft component, the requirements of the secondary allogenic components change. If autogenous material is not employed, use of a combination of particulate sizes of the allogenic component may be indicated. Thus, host site requirements and the use of other augmentation components affect whether the allogenic bone should be cortical and/or cancellous, its particulate size, and its configuration if a cortical and/or cancellous bone block is required. Various allogenic materials of every type of bone, texture, and particulate size are available, including bone blocks in a wide variety of shapes and volumes. In addition, each variation is available in treated forms to further enhance effectiveness and safety.

Xenogenic. The consistency of the xenogenic grafting material required for a specific treatment generally depends on the same considerations as when using materials of allogenic sources. Xenogenic materials are usually harvested from treated bovine cadaver bone, and are supplied in a similar array of variations useful for the many requirements of host sites.^{12,13}

Alloplastic. The consistency of alloplastic grafting materials depends on whether the case permits their use alone, or requires their use in combination with autogenous and/or allogenic and/or xenogenic materials. The character and volume of the host site, as well as the diagnostic reason for the graft, help determine the type of alloplastic material required, its density, porosity, texture, and particulate size or block shape and volume. Commonly used alloplastic materials are ceramics, composites, polymers, hydroxyapatites, calcium phosphates and carbonates, titanium oxides, and **bioactive** glass granules.⁵ Alloplastic materials are

BOX 15-2 ■ PHYSIOLOGIC CONSIDERATIONS AND PROCESSES THAT INFLUENCE GRAFTING/AUGMENTATION TREATMENT

Graft material, volume, and consistency

Presence of pluripotential stem cells

Osteogenesis

Osteoinduction

Osteostimulation

Osteoconduction

Bioactivity

dense, porous, or microporous, and sometimes have undergone treatments to enhance effectiveness and safety.

Barrier Membranes. **Barrier membrane** materials may be natural, such as the dura protecting the brain or tendons harvested from human or bovine cadavers, or synthetic, such as expanded or high-density polytetrafluorethylene (PTFE).^{14,15} Some are **resorbable**,^{16,17} and others are not and therefore must be surgically removed as part of the treatment protocol. Autogenous cortical plate is also used as a barrier.

Physiology of Grafting Materials and the Host Site. Several aspects of bone healing in general, and of bone healing following osteotomy preparation and implant insertion in particular, both in the presence of and in the absence of micromovement, are presented throughout this book. The host site provides all the elements necessary for healing. Angiogenesis is the most important process that occurs at the host site. Led by sprouting, new blood vessels extend throughout the healing area. Collagen and then bone follow their course. Biomechanical, biochemical, and bioelectric signals, some cell-mediated and others ground substance-mediated, can help initiate or enhance bone formation.^{18,19}

Certain grafting materials are **bioinert** in relation to the healing taking place around them. Others are more or less bioactive, and can enhance healing. Bioactive natural graft materials can bring their components to bear on healing, as can synthetically prepared components that have been surface **adsorbed**. The intended effect on the host site is to promote the formation of host tissues to envelop, encompass, and incorporate the graft mechanically and physiologically.

The host site healing process, and the influence of any grafting material(s) present, has given rise to an extensive vocabulary. To select an appropriate grafting material on a case-by-case basis, it is important to distinguish commonly used terms from one another and to understand their significance.

A list of many of the physiologic considerations and processes that bear on the success of grafting/augmentation is shown in Box 15-2.

Bone Graft. A bone graft is a tissue or material used to repair a defect or deficiency. It adds bulk or volume to existing bone to solve a diagnosed problem.

Pluripotential Cells. A pluripotential cell can differentiate into a fibroblast, osteoblast, osteoclast, or **erythroblast**. Only the physiologically functioning osteoblast produces bone, and this is the primary consideration in bone grafting procedures. The sources of osteoblast-producing cells at the host site are the blood supply, in which they circulate freely; the inner layer of the periosteum; and the endothelial lining of marrow spaces within cancellous bone.²⁰

Osteogenesis. Osteogenesis is the development and formation of bone. The only entity that is osteogenic is a physiologically functioning osteoblast. Osteoblasts exist at the host site and in autogenous graft material, and can differentiate from pluripotential cells from all sources.

Osteoinduction. Osteoinduction is the induction of bone formation in the absence of a bony host site. For instance, certain bone morphogenic proteins (BMPs) refined from treated cortical bone have induced the formation of bone when placed in muscle or liver tissues.^{21,22} The probable source of required osteoblasts to form bone in such locations is differentiation of pluripotential **stem cells** freely circulating in the blood supply. In a series of events not yet completely understood, BMPs signal stem cells to differentiate into osteoblasts to produce bone.²³⁻²⁵

Osteostimulation. Osteostimulation is a physiologic action that stimulates, enhances, or accelerates the formation of bone at a host site or healing endosteal implant. Osteostimulation is a far broader term than osteoinduction, in that every osteoinductive material is osteostimulatory but not every osteostimulatory material is osteoinductive. Cellular and ground substance-mediated signals of biomechanical, biochemical, and bioelectric origin are osteostimulatory. The **regional acceleratory phenomenon (RAP)** is a biochemical response to a physical injury that promotes bone healing, and is also considered osteostimulatory.^{26,27} Fifteen residue peptide (**P-15**), a synthetic peptide irreversibly bound to anorganic bovine mineral (ABM) (PepGen, CeraMed Dental), promotes the migration of reparative cells from surrounding material, and is therefore also considered osteostimulatory. This substance is supplied in particulate sizes of 250 to 420 μm . BMPs and recombinant bone morphogenic protein (rhBMP-2) are also considered osteostimulatory, as is platelet-rich plasma (PRP).

The physiologic processes that promote homeostasis and, of particular importance in implant dentistry, that maintain existing or grafted bone volume for tissue integration are known. Both hypofunction and hyperfunction of bone lead to resorption, and the functional limits between them are termed the *physiologic limits of health*.²⁸ In a sense, bone maintenance is always the goal of any treatment of bone. This goal directly bears on the concept of case engineering in implant dentistry, wherein overengineering can lead to hypofunction and bone atrophy, and underengineering can lead to hyperfunction and bone resorption.

Osteoconduction. Osteoconduction is the process by which a synthetic and inorganic material provides a bioinert scaffolding that conducts and is compatible with bone growth. Osteoconductive materials do not necessarily enhance bone formation, nor do they inhibit it. Rather, they guide the path and progress of its formation. In general, alloplastic graft materials are osteoconductive. Some are also osteostimulatory. It is interesting to note that healing around dental implants that exhibit areas of direct bone apposition at the light microscopic level is an essentially osteoconductive process.⁸

Bioactivity. In bone augmentation, the term *bioactive* is similar to the term *osteostimulatory*. Consider the enhanced bone growth observed in response to the wetting of particulate Bioglass with body fluids. Because this material is inorganic, the nature of the signals it sends to enhance bone growth is not clear, although it is hypothesized that particulate Bioglass may affect covalent bonds and alter **van der Waals forces**, as suggested for AW (alumina/woolsonite) Glass.^{29,30}

A nonreactive material that sends no ionic signals is referred to as *bioinert*.

Freeze-Dried Bone Allograft and Demineralized Freeze-Dried Bone Allograft. Freeze-dried bone allograft (FDBA) and demineralized freeze-dried bone allograft (DFDBA) can eliminate the need for a donor site. They are available in various particulate sizes, and as cortical or cancellous bone blocks of almost any shape and volume. Human cadaver allogenic material may be irradiated to reduce the immune reaction. **Desiccation** also reduces **antigenicity**. In the preparation of FDBA, calcium (Ca) and phosphate (PO_4) salts are retained to support the organic and inorganic matrices. The organic portion contains the BMPs found in cortical bone. The inorganic portion serves as a mineral source of scaffolding for bone formation. FDBA is essentially osteoconductive, because the osteostimulatory BMPs are released too slowly and in quantities too minute to be effective.⁶

DFDBA is created by removing the Ca and PO_4 salts to take better advantage of BMP for its osteostimulatory properties. Irradiation or the use of ethylene oxide (EO) for sterilization may be counterproductive because this may render the allograft unable to stimulate bone formation. DFDBA has a probability of 1 in 2.8 billion of transmitting infection with the human immunodeficiency virus (HIV). No such cases have been reported in the literature. Because only 0.01mg of BMP is yielded per kilogram of treated human cadaver bone, the synthesis of P-15³¹ irreversibly bound to ABM (PepGen, CeraMed Dental) in sufficient concentrations to be effective in the promotion of reparative cell migration from surrounding tissues represents a seminal advance in grafting/augmentation materials.

Platelet-Rich Plasma. Another emerging area is the use of platelet-rich plasma (PRP) as a grafting adjunct. This autogenous material is sequestered from the patient's blood and compacted by gradient density centrifugation. The PRP thus collected is concentrated in excess of 300%.

The beneficial ingredients of the concentrate are a platelet-based growth factor and a beta transforming growth factor. The addition of PRP to bone grafts increases the available amounts of these bone growth factors, resulting in a substantial increase in the rate of healing. Histologic examination reveals that these grafts exhibit greater bone density after healing. In-office systems are available to ensure a dependable fresh supply of PRP to use in conjunction with a variety of implant dentistry procedures.

CLINICAL CONSIDERATIONS THAT INFLUENCE SUCCESSFUL BONE GRAFTING

Successful bone grafting in dentistry requires the presence of and proper relationships among several factors to ensure success, as listed in Box 15-3. Some of these factors may be naturally present in a case, and others may not. A definitive diagnosis is therefore essential to determine which required factors are present at the host site, and which must be added. The main factors that contribute to success are an adequate local host blood supply; the absence of actual or probable infection (an antiseptic host site); the ability to achieve dependable and secure soft-tissue coverage; the nature, size, and shape of the host site; provision of adequate healing time; ability to seed the graft with fresh autogenous bone; the use of treated allogenic and xenogenic graft materials; the use of alloplasts as required; protection of extensive grafting during healing; graft immobilization during healing³²; availability of collagen inclusion during healing; bone mineralization requirements during healing; and treatment of complications. Certain systemic conditions and habits such as smoking may contraindicate a grafting/augmentation procedure.³³

Soft-Tissue Coverage

Secure, dependable closure following grafting is essential to success. First, determine that soft tissue is sufficient following grafting to allow for tension-free closure. In cases of extensive grafting, carefully estimate the potential adequacy of soft tissue for closure before placing the material. The most common postoperative complication of grafting is dehiscence at the suture line.

If insufficient tissue is present when the soft-tissue flaps are coapted, reflect tissue a bit more extensively, and/or carefully score the periosteal lining of the inner portion of the flap with relief incisions, and by applying tension, expand the soft tissue. Preserve as much attached gingiva as possible. The second important element of dependable soft-tissue closure is adequate suturing. Try to avoid friable tissue while suturing, and when possible penetrate through tough, dense, attached gingiva, taking a deep bite with the needle. Generally, 3-0 black silk interrupted sutures are placed with atraumatic needles. For friable tissue, 4-0 sutures are used. Tension-free suturing is required to avoid tearing tissue. No particulate grafting material should remain in the suture line. If a removable prosthesis

BOX 15-3 ■ CLINICAL CONSIDERATIONS THAT INFLUENCE GRAFTING/AUGMENTATION TREATMENT

- Soft-tissue coverage
- Infection control at host site
- Volume and configuration of defect
- Use or absence of autogenous bone in graft
- Protection of extensive grafting during healing
- Adequate healing time
- Graft immobilization
- Host blood supply
- Bone mineralization requirements

is to be replaced provisionally following grafting, relieve the tissue surface over the grafted area.

Aseptic Host Site/Infection Control

Infection lowers pH, and among other complications causes accelerated resorption of some grafting particulates. Do not graft in the presence of probable or actual infection. Even the resident bacterial population of the oral cavity can contaminate a graft. Grafting materials may be mixed with antibiotics such as parenteral penicillin or clindamycin. Tetracycline, commonly used in periodontal grafting related to collagen regeneration, is not advised for bone augmentation, because it **chelates** calcium and retards bone formation.

Volume and Configuration of the Defect

Think of a potential grafting host site as though it were a lidded box. Six walls surround a void. This void is the augmentation host site. If the lid is removed, a five-wall configuration results. As walls are removed, the procedure becomes more challenging, until one is faced with the demanding treatment required for a one-wall host site requiring an **onlay graft**.

Consider treatment of an extraction site in which the residual socket has five walls. With no infection present; an adequate amount of acceptable soft tissue for secure, dependable, strain-free closure; and an ideal host blood supply, the site is perfect for grafting. In this hypothetical case, several of the aforementioned prerequisites for successful grafting are in place, such as absence of infection, the ability to perform secure tension-free closure, ideal configuration and volume of the defect, and adequate host blood supply from both hard and soft tissues. Because hydroxyapatite is the principal inorganic component of bone and teeth, it is a logical choice for grafting fresh extraction sockets. Grafting a four- or five-wall defect with resorbable hydroxyapatite maintains the ridge anatomy and reduces the negative effects of residual ridge resorption on the final prostheses.

A synthetic, resorbable hydroxyapatite (OsteoGraf/LD-300, CeraMed Dental, Lakewood, Colorado) will resorb through solution mediation.³⁴ This dissolution process releases calcium and phosphorous, and provides a scaffold for initial bony proliferation. The particulate supplied is pure, with a consistent particle size range of 250 to 420 μm . Because of its bulk, it also acts as a barrier to inhibit soft-tissue ingrowth.

Tooth removal should be performed as atraumatically as possible. Preservation of the bucco/labio-lingual width of the arch aids in esthetic reconstruction. After the tooth has been removed, thorough curettage of the socket walls is essential. The formation of new bone in a four- or five-wall defect, such as an extraction socket, occurs by adhesion to existing bone. Irrigation and aspiration complete the preparation of the socket to accept the graft material.

Placement of the hydrated grafting material is accomplished in approximately 5-mm increments to ensure uniform density. Each layer is applied into the socket firmly but remains loose enough to permit blood supply throughout the area. The close approximation of the grafting material to the fresh bony socket wall optimizes the osteostimulatory potential of the site.

Primary closure over extraction sites usually is difficult. Epithelium proliferates from the margins of the wound at a rate of approximately 0.5 mm per day, to help seal over the socket to complete the coverage and retain the graft material. Healing immediately following the extraction and grafting must be protected. If tissue available for closure seems inadequate, a containment device is needed. A surface-acting hemostatic material such as Gelfoam protects closure, slows the flow of blood, and offers a framework for the deposition of cellular elements. This is an inexpensive way to achieve containment of the graft material.

Preservation of ridge height and width is the benefit of this procedure. This is an ideal way to introduce bone grafting into a clinical practice.

Clinically, few cases ideal for grafting immediately following tooth extraction exist. More often, teeth are removed precisely because of inflammation and infection. Also, tissue closure over a fresh extraction site often creates excessive tension at the closure line, or is not possible at all. For these reasons, approximately 4 weeks of healing should be allowed after tooth removal before grafting is performed. This time period resolves any present infection and allows adequate soft tissue for dependable, secure closure to mature and keratinize. Dependable, secure, tension-free suturing is possible, and success is more predictable. The disadvantages of this delay are the need for extended treatment time and an additional surgical intervention.

The socket can heal without grafting, but with the loss of ridge height and width. Five-wall and four-wall sockets or defects of other etiology require only small amounts of autogenous, allogenic, xenogenic, and/or alloplastic grafting particulate. Following grafting, allow 5 to 6 months of healing before inserting a dental implant. An exception is when an implant inserted into a new extraction site fits imprecisely into its extraction site/implant osteotomy.⁶

Autogenous Bone

An important component of predictable bone grafting, autogenous bone is the only material that forms bone with the aid of transplanted osteoblasts generally sourced from cancellous bone. This cancellous bone provides few BMPs, if any.⁸ Osteoconductive human cadaver bone products are not viable. If autogenous bone is used, a minimal time between harvesting and grafting is advised to retain as much cell viability as possible. In all instances in which autogenous bone is used, it is placed directly against or into the host site.¹¹

Protection of Extensive Grafting During Healing

As the number of walls at the host site decreases, the need for an artificial means of retaining grafted particulate in the host site increases. Grafting against one- or two-wall sites requires that no functional forces be applied to the site, because compression of the graft may alter volume and configuration and may cause mobility. Thus, if a removable denture is used, it must be relieved generously over and around the graft. Tent screws, barrier membranes, and sometimes autogenous, allogenic, or xenogenic bone blocks can be used for this purpose.¹¹ These represent intermediate and advanced bone grafting cases.

Adequate Healing Time

Required healing time varies case by case. If in doubt, opt for additional healing time. Variation in required healing time is related to graft volume, configuration, and host site location, and whether or not autogenous bone is used. Generally, grafts up to 5 to 6 mm² require up to 6 months to heal, while larger grafts require up to 10 months.

Graft Immobilization

If one incorporates the graft within the anatomy of the host site, mobility may be absent.³⁵ Movement reduces the value of the host blood supply, and may promote fibrous encapsulation and sequestration of the graft. In cases of larger grafts with fewer bony host site walls, screw fixation can promote immobilization during healing. Again, provisional dentures, if used, are relieved over all grafts.

Host Blood Supply

Host blood vessels invade the graft to supply cells and nutrients. Vascularization may extend from the rich vascular network in the cancellous bone, cortical bone (which should be liberally fenestrated, and occasionally removed to accelerate angiogenesis), and nearby soft tissues of the host site. In addition, pluripotential cells of the inner layer of the periosteum and the endothelial lining of host marrow spaces are stimulated by grafting procedures, and contribute to the rate and quality of bone healing.

Bone Mineralization Requirements During the Healing Process

Role of Collagen. At the time of the earliest woven bone formation, type I collagen is synthesized by the body and incorporated into the healing process.³⁶ An additional source of collagen can be DFDBA, although this material is rarely used alone. Certain xenogenic grafts (ABM) that are irreversibly bound with a synthetic P-15 help fulfill collagen requirements.³¹

Role of Calcium and Phosphate Salts. Calcium and phosphate salts are required for the mineralization of healing bone and grafts. They are derived from the host site blood supply and nearby host bone, with contributions from autogenous and allogenic particulate. Alloplasts of Ca and PO₄ and xenografts are also a source of calcium and phosphate salts. They may be used to occupy space and thus prevent ingrowth of fibrous tissue into areas in which bone is desired. In this sense, alloplasts can serve as barriers in a combination of grafting materials.^{37,38}

GRAFTING COMPLICATIONS

Complications are well documented and variable because of differences in host site location, volume, configuration, and physiologic and functional deficiencies that, when diagnosed, led to the need for grafting. Improper diagnosis, treatment planning, grafting materials selection, and/or case sequencing can all cause complications. In addition, poor soft-tissue management, the immediate placement or placement of too many implants into a graft at the time of surgery in certain cases, inadequate planning at the time of grafting to provide for proper esthetics, the presence of undetected sinus or periapical pathology at the time of grafting, periodontal disease, and certain adverse systemic and local conditions can compromise soft-tissue and/or bone healing following grafting.

Biomechanically, a graft may be unable to function within physiologic limits of health if, for example, too many or too few implants are placed into an autogenous graft. However, the greater the number of implants placed at the time of grafting, the more one risks improper placement, host bone fracture, or block graft cracking or fracture. Failure to institute progressive and careful bone loading of large autogenous grafts can lead to complications.

Common postoperative complications are wound dehiscence, pain, and sinusitis. Poor flap design can compromise blood supply. For reasons not fully understood, poor soft-tissue management over autogenous grafts can lead to significant complications, to the extent that in most cases it is advised that implants only be inserted into autogenous grafts following healing.

Autogenous soft-tissue grafts and gingivoplasty are often required for graft patients. Grafts are best stabilized with fixation screws, not with implants. Stabilization wiring techniques are not as predictable as fixation screws.

TREATMENT OF ENTRY-LEVEL GRAFTING CASES

Considerations Common to Entry-Level Cases

Entry-level grafting procedures have many of the following considerations in common. Sufficient soft tissue for secure, dependable closure of the graft site is present, or can be provided easily. The site is free of infection. The volume of the host site defect is minimal, to the extent that bone blocks are not required. Particulate material is used, which can easily graft irregularities of any configuration. Entry-level cases have four or five osseous walls to support the grafting material, except for minor perforation during osteotomy preparation for an endosteal implant. The small amount of autogenous bone used, if any, is harvested from the host site as part of the curettage process for creating an ample fresh vascular bed. The problem of inadequate host site vascularity at the site of an osteotomy perforation resulting in a one-wall defect in cortical bone is solved by decorticating the area, or piercing the host site liberally through cortical bone and into cancellous bone, to produce a vascular bed and viable bone cells. Entry-level grafts need little protection because their exposed areas are small and may be encased in four or five host site walls. Barrier membranes are not required.

Examples of Entry-Level Grafting Cases

Grafting into new or recent extraction sites, to cover exposed threads or interface of a dental implant at the ridge crest, to cover the recessed shoulder of an inserted plate/blade form, to seal a perforation below the ridge crest during osteotomy preparation, to even areas of an exposed ridge crest that harbored a retained root or residual granulation tissue, to fill small areas around dental implants seated into immediate extraction sockets, and to supplement areas around dental implants seated into expanded ridges following the use of osteotomes are all considered entry-level grafting cases.

Selection of Grafting Material

Because of the graft's minimal size and the ample blood supply at the curetted or fenestrated bed of the host site, autogenous bone need not be harvested. Allogenic grafts are generally used for entry-level cases; sometimes, xenogenic grafts are used. Alloplasts, which are most effective in providing scaffolding and bulk for large treatment areas, are used less often in entry-level cases, in which the size of the treatment area is usually small. P-15 (Pep-Gen, CeraMed Dental) can provide a biomimetic environment for bone regeneration, and PRP can also be an efficacious grafting adjunct.

Grafting Procedure for Entry-Level Cases

Following tissue reflection, the host site is exposed. The host site is curetted or fenestrated to create an ample vascular bed seeded with viable cells. The chosen graft material is inserted

or carefully applied against the host site. Soft-tissue flaps are coapted and securely sutured. No grafting material remains within the suture line. Sutures are removed 10 to 14 days postoperatively. Ample time for healing is allowed. The pre- and postoperative considerations common to the mainstream applications of the abutment-providing modalities, such as protection from excessive load and maintenance of proper diet and hygiene, also apply for entry-level grafting procedures. The details of this procedure were discussed previously in the section on volume and configuration of the defect.

ALVEOLAR RIDGE EXPANSION

In implant dentistry, the object of bone enhancement is to increase the volume and improve the contours of available bone to enable implant insertion into areas that can sustain long-term function. In the case of endosteal implants, and particularly in the case of root forms, the dimensions of the implant may preclude insertion into residual alveolar ridges with insufficient bucco/labio-lingual width. To mitigate the need for the use of bone block grafts to increase ridge width, because of the technique-sensitivity and more guarded prognosis of such treatment, the concept of ridge expansion evolved. Through the serial use of graduated chisel-like, cylindrical, or tapered cylindrical osteotomes, thin ridges can be slowly expanded to increase their width.³⁹

Clinical Considerations

The most common anatomic area in which ridge expansion is performed is the anterior maxilla, followed by the posterior maxilla, and then the anterior and posterior mandible. As discussed in Chapter 3, the residual alveolar ridge in the maxilla is variable, and has a much higher percentage of cancellous bone than in the mandible. Cancellous bone is pliable, and when treated carefully, can be slowly expanded. In the case of the tapered Innova Endopore implants, a series of graduated tapered osteotomes are available for this purpose. If exposure of the ridge reveals inadequate width, a primary penetration is made at the crest in the planned long axis of implant insertion with a 1-mm diameter XL carbide bur in a high-speed contra angle with copious coolant. After penetrating 5 to 7 mm, the bur is moved mesially and distally no more than 2 mm. A small, tapered cylindrical osteotome is introduced, aligned axially in the direction of intended implant insertion, and tapped apically with a mallet to the correct depth for the chosen implant. The assistant supports the ridge crest with finger pressure applied from both the labial and lingual during malleting. A second osteotome is introduced and malleted to the appropriate depth, and then a third graduated osteotome if required, to finally coordinate with the diameter and depth of the selected implant. Seated round osteotomes are removed by rotating them only clockwise to loosen their hold. Rotating both clockwise and counterclockwise can overexpand the site. The coordinated trial fit gauge is malleted to position and twisted clockwise

for removal, and the implant is inserted. Crestal voids at the mesial and distal of the implant, if present, are grafted. The case is sutured.

The parallel-sided Nobel Biocare/Steri-Oss RHL Immediate Insertion Implants use coordinated, graduated, parallel-sided osteotomes in a manner similar to that described for the Innova Endopore implants.

The Oratronics plate/blade form implants use graduated, tapered chisels inserted into preliminary osteotomies and malleted to the desired depth to expand the ridge slowly. These are removed through mesial and distal tilting only.

In many ridge expansion cases, implants are not immediately inserted. Rather, slow-resorbing hydroxyapatite or another grafting material may be used to graft the internal void within the expanded ridge. For example, ABM (OseoGraf/N-Block, CeraMed Dental) in block form can be contoured for insertion into an expanded ridge. This type of graft benefits from excellent protection, stability, and host blood supply. The grafted site is sufficiently rigid to maintain the desired architecture and reduce the risk of ridge relapse during healing. The graft remodels to vital bone through a cell-mediated resorption mechanism. After healing for 6 months, the expanded and grafted ridge is exposed to prepare the osteotomies for implant insertion. Dense, nonresorbable ceramic alloplastic grafting material is not used in such cases because it is difficult to penetrate for osteotomy preparation.

Dental implant insertion in an expanded and grafted ridge is considered an intermediate or advanced procedure.

NERVE REPOSITIONING

Cases that require nerve repositioning are rare. In implant dentistry, nerve repositioning is performed to increase the volume of available bone for the insertion of endosteal implants, or in the case of subperiosteal implants, to permit a superior framework design.

Clinical Indications

Nerve repositioning treatment is usually performed in the mandible. Rarely, to enable deeper seating of an endosteal implant in an advanced case, an osteotomy is planned to pass either lingual or buccal to the inferior alveolar nerve. In such cases, the nerve is approached from the buccal and carefully repositioned either lingually or as close to the buccal as possible. This creates a zone of safety either to the buccal or lingual of the repositioned nerve for the preparation of one or more osteotomies.

In subperiosteal implantology, a mental nerve that exits the mental foramen at or near the crest of the ridge can compromise the location and strength of the buccal main bearing struts designed to clear the nerve at implant seating. To correct this, the position of the mental foramen can be surgically lowered by judicious removal of bone, and the mental nerve repositioned apically as it exits the altered area.



FIG. 15-1 ■ Predistraction radiograph (lateral view). (Courtesy David Walker, Toronto, Canada.)

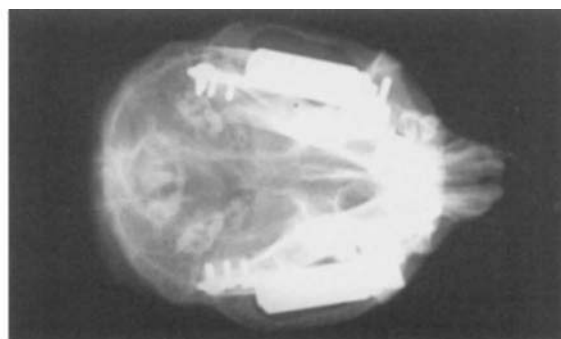


FIG. 15-3 ■ Distractors in position preactivation (inferior view). (Courtesy David Walker, Toronto, Canada.)



FIG. 15-2 ■ Distractors in position preactivation (lateral view). (Courtesy David Walker, Toronto, Canada.)

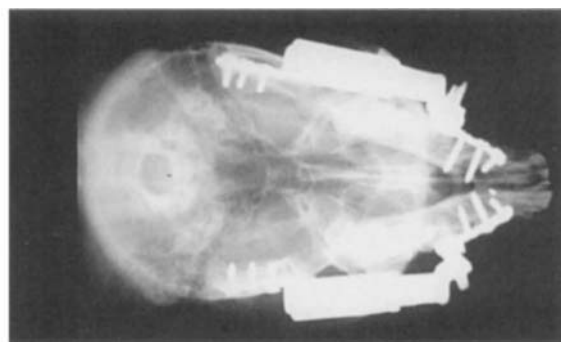


FIG. 15-4 ■ Distractors in position postdistraction (inferior view). (Courtesy David Walker, Toronto, Canada.)

Other clinical conditions may indicate treatment requiring nerve repositioning. These procedures are generally considered to be at the advanced level of practice.

DISTRACTION OSTEOGENESIS

A treatment that is currently gaining acceptance to enable predictable extension or lengthening of bone is **distraction osteogenesis**.^{40,41} In implant dentistry, this technique has direct applications for patients with micrognathia and associated occlusal disharmony. As part of the preinsertion regimen in implant dentistry, correction of an unfavorable occlusal relationship is accomplished first to improve the prognosis of implant-supported prostheses. In addition, the esthetic improvement can be striking.

Clinical Considerations

Distraction osteogenesis is a process by which bone is gradually lengthened by the action of an appliance following the creation of a sectioning osteotomy at the anatomic area at which additional bone is desired. Historically, in repositioning the mandible, such appliances have been placed with an extraoral mechanism to control the rate of separation—distraction—of the surgically separated por-

tions of bone. Bone continuity is reestablished as new bone forms across the created segmental defect.⁴²

Some root form systems are designed to take advantage of the benefits of distraction osteogenesis to increase alveolar ridge crestal height and/or width during the healing stage.⁴³ Long-term evaluation is required for proof of the predictability, safety, and efficacy of such systems.

The current state-of-the-art technology for distraction osteogenesis is represented by the Innova Bi-directional Telescopic Mandibular Distractor. This boneborne device is placed transorally directly against the lateral border of the mandible, distal to the mental foramen, and inferior to the inferior alveolar canal (Figs. 15-1 to 15-3). This placement precludes paresthesias, and avoids the percutaneous screw and pin tract scars and supplemental bone augmentation associated with extraoral fixation. The appliance remains submerged in the mucosa, and after installation and a 7-day period of quiescence, transoral appliance activation lengthens and positions the mandible in two planes for optimal control. Distraction takes place at the rate of 1 mm per day, until desired correction is achieved (Fig. 15-4). Following correction, the submerged devices are left in place for 2 to 3 months to allow consolidation of the new bone, and then removed (Fig. 15-5).



FIG. 15-5 ■ Two months' healing after distractor removal (lateral view). (Courtesy David Walker, Toronto, Canada.)

Distraction osteogenesis procedures are considered to be at the advanced level of treatment.

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16 Choosing the Appropriate Implant Modality

The three professionally accepted abutment-providing modalities covered in the teaching case chapters are safe and effective for their intended purpose of providing abutment support, and are sufficiently technique-permissive to be incorporated into the normal routine of most practitioners. Whereas each is known to be scientifically acceptable in terms of safety and efficacy,¹⁻⁶ the three differ markedly with regard to the clinical criteria for professional acceptance described in Chapter 7. This affects diagnosis and patient acceptance.

In most cases properly diagnosed for mainstream treatment, one of the modalities presents itself as being the most appropriate for treatment in consideration of the preoperative volume of available bone. In some cases, for example, only the plate/blade form modality can be used for mainstream treatment, because available bone is insufficient for root form placement⁷ and overabundant available bone precludes subperiosteal implant placement. For other patients, only the subperiosteal implant may be applicable, because a lack of available bone rules out use of any endosteal modality without extensive non-mainstream bone augmentation procedures.^{8,9}

In cases in which available bone is sufficient for use of the root form modality, plate/blade forms may also be used. Because of frequent lack of adequate available bone depth posteriorly, conventional root forms can be used in approximately half of the cases that present for mainstream treatment. The Innova Endopore implant used in the posterior partial edentulism teaching case presented in Chapter 11 increases the applicability of the root form modality, because its diffusion-bonded microsphere interface increases its surface area to the extent that it can be approximately two thirds the depth of a conventional root form.¹⁰ These considerations reaffirm the diagnostic importance of accurately quantifying available bone, in all its variations, because of its profound effect on treatment planning and implant modality selection. It is precisely because no one implant modality can be used for the mainstream treatment of every case that practicing multimodal implant dentistry is of benefit to the practitioner and patient alike.

This chapter demonstrates how available bone governs much of diagnosis in implant dentistry. Available bone requirements are quantified for mainstream treatment using each modality, allowing one to empirically determine if any given modality is applicable to the case at hand. In the presence of insufficient or overabundant bone, when one modality cannot be considered for mainstream treatment, another one can. In cases of overlap, more than one modality is appropriate for the available bone presented. Scientifically, the overlapping modalities are equally valid, insofar as each can safely and effectively provide additional abutment support for restorative dentistry. In such cases, one should apply the clinical criteria for an ideal implant system, provided in Chapter 7, to the modalities under consideration. If two modalities can be used safely and effectively, considerations such as time, esthetics, cost, complexity, and trauma become important, and can guide the practitioner to make the decision that most benefits the patient.¹¹

The broader message of this chapter is that the combined scope of treatment using all three abutment-providing modalities—the multimodal approach—is far greater than the scope of treatment exclusively using any one modality. Collectively, the use of these three modalities represents the true scope of treatment possibilities afforded by implant dentistry.¹² Every practitioner should understand the indications and contraindications of each modality, and share this understanding with patients considering treatment.

DETERMINING WHETHER IMPLANT TREATMENT CAN SUCCEED

Determining whether implant treatment can succeed is one of the most important concepts in implant dentistry, and is a consideration that must be incorporated into the diagnosis and treatment planning routine of every implant dentistry practitioner in every case. If a dental implant of any kind is placed successfully into or onto the available bone, heals properly, and is fitted with its final prosthesis, will it be able to withstand the anticipated load? Can it do

the job asked of it? Just because an implant can be placed and heal successfully does not mean that it will be able to withstand the forces to which it will be subjected. Not every implant configuration can support an equal load long-term in health. The various implant configurations exist to advantageously use the various volumes and configurations of available bone one encounters in candidate implant dentistry patients.

If it is deemed likely that an implant considered for use in a case would not remain in health long-term, the treatment plan should be changed, or the case may fail. This is the same consideration applied to evaluate potential natural abutments in conventional prosthodontics, in that sometimes a natural tooth available for abutment support may be deemed unable to bear the load in health long-term, and therefore is avoided or splinted to other teeth.

In a way, asking an entry-level practitioner to make this determination is premature. Realistically, one cannot accurately determine how much load an implant should be able to withstand until one has gained experience observing the course of several mainstream cases. Generally, if one follows the guidelines established in Chapter 1 to determine whether a case is mainstream, an implant appropriate for the available bone will be able to withstand the anticipated load. Cases similar to the teaching cases discussed in the step-by-step procedure chapters should succeed. However, in any type of case, including the most predictable of mainstream cases, it is important to be sure that one is asking the implants to do a realistic job. The case must not be underengineered. This consideration gains in importance as one progresses toward treating intermediate and advanced cases, in which the capability of the implants to withstand anticipated load cannot be taken for granted. Proper case engineering is essential. In intermediate and advanced cases, the judgment of the practitioner has a greater influence on the ultimate outcome of the case.

In addition to evaluating available bone, the practitioner must consider the nature of the patient. Is the patient a gentle, weak, or aged person, or a vigorous person and a habitual bruxer? Other factors such as the opposing dentition must also be taken into consideration. For example, an opposing removable denture affords more shock absorption than natural teeth and therefore will impart less force to the implant-supported prosthesis. Proper occlusion is also an important consideration.

AVAILABLE BONE AS THE PRIMARY DIAGNOSTIC CONSIDERATION

Mainstream Cases Use Existing Available Bone

Mainstream cases use the available bone that exists preoperatively. It is a fundamental precept of mainstream implant dentistry that the implant should be selected to fit the anatomy and volume of the available bone, and that the available bone should not need to be altered or augmented substantially to accommodate a specific implant modality. As discussed in Chapter 15, bone en-

BOX 16-1 ■ IDEAL AVAILABLE BONE PARAMETERS FOR A ROOT FORM WITH 4-MM DIAMETER AND 10-MM DEPTH

Bucco/labio-lingual width: 6 mm
Mesio-distal length: 8 mm
Depth: 12 mm

hancement techniques can change the anatomy of the alveolar ridge, sometimes radically. However, such techniques are not considered mainstream because of the complexity of treatment, insufficient long-term success and survival data, and lack of general consensus on preferred materials and methods of placement for different types of treatment. The prognostic value of altering an alveolar ridge to fit a preselected implant modality or configuration is questionable. It is certainly easier to select an implant that fits the available bone as presented. Abundant long-term success and survival data support such a course of action. Chapter 8 presents some of these data.

Range of Available Bone Volume Suitable for Each Implant Modality

This section analyzes the available bone that is typically required for each of the abutment-providing modalities, dimension by dimension, and identifies the conditions in which only one modality can fit the available bone to provide mainstream treatment.

Root Forms. The ideal available bone parameters for a typical conventional root form configuration are shown in Box 16-1. No available bone presentations exist for which only the root form modality can be used to provide mainstream treatment.

Bucco/Labio-Lingual Available Bone Width. The width of a root form implant is its diameter. It is best to have 1 mm of crestal bone width at the bucco/labio-lingual borders of any endosteal implant on the day of insertion. Three-dimensional finite element analysis in conjunction with clinical observation indicates that this is generally the minimum amount of investing bucco/labio-lingual bone required at the ridge crest to absorb functional loads within physiologic limits of health.¹³ The reason that the amount of required investing bone at the ridge crest is smaller than in other areas is because cortical bone offers more support. Clinically, in mainstream cases, this means that a conventional root form implant with a diameter of 4 mm requires a pretreatment ridge width of 6 mm as measured 1 to 2 mm apical to the ridge crest.

Mesio-Distal Available Bone Length. Because a root form is round in cross section, its length is its diameter. If a root form is inserted adjacent to a tooth or another root

**BOX 16-2 ■ IDEAL AVAILABLE BONE
PARAMETERS FOR A PLATE/BLADE FORM
WITH 18-MM LENGTH AND 8-MM DEPTH**

Bucco/labio-lingual width: 3.35 mm
Mesio-distal length: 22 mm
Depth: 10 mm

form, a minimum of 2 mm of clearance between them is recommended in mainstream cases. This amount of proximal bone is required because the mesial and distal of the implant interface is almost entirely against cancellous bone. There is a much higher percentage of cortical contact against the buccal/labial and lingual interfaces.¹⁴

Available Bone Depth. Conventional root forms used for mainstream implant dentistry treatment are typically 10 mm deep. It is advised to have approximately 2 mm of clearance beyond the apical end of the implant to the nearest landmark. Thus, for conventional root forms, 12 mm of available bone depth is generally recommended. It is permissible to reduce the height of the ridge crest to create the sufficient ridge width provided that in doing so a sufficient depth of available bone remains from the reduced crest to the nearest landmark to place the implant with 2 mm of clearance.

Plate/Blade Forms. The ideal available bone parameters for a typical plate/blade form configuration are shown in Box 16-2. When evaluating available bone for insertion of a plate/blade form implant, it is useful to know that in general, an inverse relationship exists between the implant's length and depth. A longer configuration requires less depth to function within physiologic limits of health long-term, whereas a configuration that is shorter mesio-distally requires greater depth.

The plate/blade form is the only modality that can provide mainstream treatment in cases within certain ranges of available bone depth and width.

Bucco/Labio-Lingual Available Bone Width. Most plate/blade forms are 1.2 to 1.35 mm in width. Thus, with 1 mm as the minimum required width of investing bone buccally and lingually, the minimum ridge width for insertion of a plate/blade form in a mainstream case is 3.35 mm as measured 1 to 2 mm below the crest. This relatively small width requirement is the primary reason that plate/blade forms have such wide diagnostic applicability.

In cases with sufficient depth of available bone for the insertion of an endosteal implant but width less than 6 mm, the plate/blade form modality is indicated.

Mesio-Distal Available Bone Length. A minimum of approximately 2 mm of clearance should exist between the mesial or distal border of a plate/blade form and an adjacent tooth root or other implant.

Available Bone Depth. Using any plate/blade form configuration, 2 mm of clearance is ideal between the

**BOX 16-3 ■ AVAILABLE BONE MAXIMUMS
FOR A SUBPERIOSTEAL IMPLANT**

Bucco/labio-lingual width: No limit
Mesio-distal length: No limit
Depth: 6-8 mm posteriorly, 8-12 mm anteriorly

implant and any landmarks beyond its depth. In mainstream cases, ridge crest height rarely needs to be reduced to create the sufficient ridge width of 3.35 mm. In cases in which depth of available bone is 6 to 10 mm, the plate/blade form modality is usually the only modality indicated.

Subperiosteal Implants. The maximum available bone parameters for placement of a subperiosteal implant are shown in Box 16-3. Whereas in endosteal implant dentistry insufficient available bone can contraindicate the use of a configuration, in subperiosteal implant dentistry overabundant alveolar bone is a contraindicating factor. Therefore, whereas in endosteal implant dentistry minimum available bone requirements are considered, in subperiosteal implantology the maximum available bone that allows a satisfactory prognosis is considered.

Subperiosteal implants are the only modality that can offer mainstream treatment when available bone depth is insufficient for placement of an endosteal implant.

Bucco/Labio-Lingual Width. In subperiosteal implant dentistry, width is not a limiting factor, although greater width is desirable.

Mesio-Distal Length. Length of available bone is not a limiting factor in subperiosteal implant dentistry. In mainstream unilateral subperiosteal cases, in which the prosthesis is supported by a combination of implant and natural co-abutments, the length of the implant is naturally dictated by the length of the edentulous span. When relatively fewer teeth have been lost, the length of the implant is relatively short, and total support of the prosthesis is compensated by the fact that more natural tooth co-abutment support remains. When more teeth have been lost, the implant length, and therefore the amount of support offered by the implant, increases with the length of the edentulous span onto which the implant is designed, and the number of teeth planned for the overlying prosthesis increases.

Available Bone Depth. Excessive depth from the ridge crest to the nearest landmark contraindicates the use of a subperiosteal implant. In cases in which there is sufficient residual alveolar ridge to insert endosteal implants that can function within physiologic limits of health, endosteal implants should be used.

The maximum acceptable depth of available bone for mainstream treatment using a posterior unilateral subperiosteal implant is 6 to 8 mm. In the presence of less

than this depth, subperiosteal implants are ideal. In fact, in such cases, only the subperiosteal implant modality is indicated. This is also true in cases with 6 to 8 mm of available bone depth but less than 3.35 mm of width as measured 1 mm below the ridge crest, because this lack of width contraindicates insertion of a shallow plate/blade form despite adequate depth. When more than 6 to 8 mm of bone depth is available with sufficient ridge width, endosteal implants are better suited for the case at hand. Anteriorly, the maximum available depth allowable for mainstream treatment using a subperiosteal implant increases by 2 to 4 mm, and sometimes more, depending on the width of the ridge crest and other factors.

Incidence of Appropriate Available Bone for Each Modality

Having a general idea of the range of anatomic presentations typically encountered in implant dentistry candidates is helpful in deciding which modality or modalities to learn first. For practitioners who use one modality exclusively, general knowledge of the range of anatomic presentations helps one determine which modality to learn next to offer mainstream treatment to more patients.

Root Forms. Many partially edentulous implant dentistry candidates who present for treatment have insufficient available bone for mainstream root form implant insertion. It is interesting to note, however, that most implant treatment performed today uses root form implants. In essence, the majority of our resources has been devoted to treating a minority of implant candidates.

This fact highlights the benefits of the multimodal approach, which enables the treatment of a broader range of patients. At the same time, our discipline's focus on the root form implant has provided abundant data on the modality's long-term safety and efficacy, voluminous scientific literature detailing various insertion and restoration techniques, and an established network of corporate entities and practitioners to whom one can turn for support.

Plate/Blade Forms. Plate/blade forms have the broadest range of applicability of the abutment-providing modalities. Most patients who are candidates for implant dentistry can be treated using the plate/blade form modality. A patient whose anatomy allows use of root form implants can receive plate/blade form implants. In cases in which either mainstream root form or plate/blade form treatment can be performed, the practitioner should, in consultation with the patient, decide which modality is better suited based on important clinical criteria such as length of treatment, the desirability of using or avoiding natural co-abutments, number of patient visits, total weeks in treatment, and cost. Practitioner comfort and familiarity with the modality options may be the most important consideration in such cases.

Despite the high percentage of candidate patients who can be treated using the plate/blade form implant modality, one should not adopt a single-modality approach in favor of plate/blade forms. The number of patients who can

be treated using multiple modalities remains substantially higher.

Subperiosteal Implants. Only a small percentage of implant dentistry candidates can undergo mainstream treatment using a unilateral subperiosteal implant, because most patients present with sufficient available bone for insertion of an endosteal implant. However, this does not mean that the subperiosteal is the least important modality. On the contrary, it is the small percentage of patients for whom mainstream treatment using a unilateral subperiosteal is appropriate who have the greatest need. These patients typically have had the most dental complications in their lives and are almost out of treatment options. Furthermore, in most cases in which mainstream treatment using a unilateral subperiosteal implant is indicated, no other modality can be used without extensive non-mainstream bone augmentation. There is very little overlap with this modality. Therefore, the subperiosteal implant is one of the most important modalities to learn, because it is usually the only mainstream option for those patients who require it.

MAINSTREAM CASE ANALYSIS—WHEN MORE THAN ONE MODALITY CAN BE USED

In overlap cases, in which more than one modality may be applicable to the available bone, clinical acceptance criteria help the practitioner determine the appropriate modality for use. The underlying assumption when using clinical criteria to assist in selecting the most appropriate modality in any given overlap case is that everything else is equal. In other words, the two modalities that are applicable have equal scientific validity—that is, they each have been proven safe and effective for their intended purpose. All of the professionally accepted implant modalities discussed in this book have proven scientific validity. That is why the clinical criteria are so important in choosing between them. Using clinical criteria also presupposes that the available bone requirement is equally suitable for either modality—that there is, in fact, overlap. If not, mainstream implant dentistry treatment dictates that the modality that fits the available bone be used.

Overlap Between the Subperiosteal and Plate/Blade Form Modalities

In cases in which either the subperiosteal or plate/blade form implant modality may be used (Fig. 16-1), in which the depth of available bone is approximately 6 to 8 mm and the width equals at least 3.35 mm as measured approximately 1 mm below the ridge crest, the practitioner must determine which modality is preferable. Interocclusal clearance, the presence of adequate natural co-abutments, the presence of natural teeth or a denture in the opposing arch, habits, emotional need, the practitioner's familiarity and comfort level with the two modality options, and the like all bear on this decision. Other important considera-

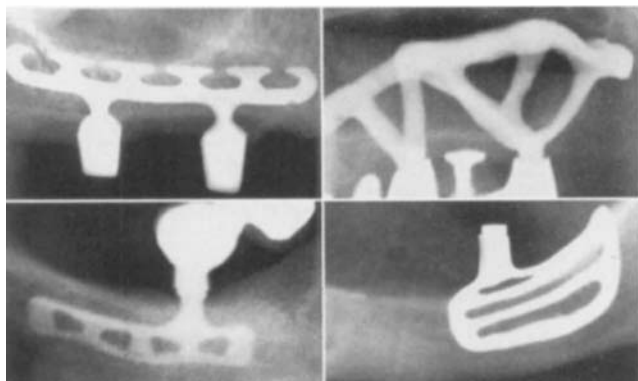


FIG. 16-1 ■ Similar shallow available bone presentations treated with maxillary plate/blade form implant (*upper left*), mandibular plate/blade form implant (*lower left*), maxillary unilateral subperiosteal implant (*upper right*), and mandibular unilateral subperiosteal implant (*lower right*).

tions are related more closely to the patient's desires, needs, and temperament. If the patient is reluctant to undergo the two-stage surgical protocol usually followed to place a subperiosteal implant, then inserting one or several shallow blades may be a superior option.

The practitioner must determine which modality has less potential for complications. The risk using a subperiosteal implant in a borderline case is that the bone on which the implant is placed may further resorb under portions of the implant to the extent that struts may dehisc through the gingiva into the oral cavity. The risk using shallow plate/blade forms in a borderline case is that the anticipated occlusal load may not permit the implants to function long-term within physiologic limits of health. The case must be sufficiently engineered. Another important consideration is whether the patient is able to perform acceptable home care. Because the subperiosteal implant requires more conscientious home care, it may be advisable to use shallow plate/blade forms when possible for patients who have a history of inadequate home care.

The option of inserting shallow blades and reserving the placement of a subperiosteal implant as a fallback plan is worthy of consideration in such cases. Subperiosteal implants are often the final resort in implant dentistry,¹⁵ and it is sometimes advisable to treat with another modality first, knowing that the subperiosteal implant may be used later if the initial endosteal treatment is unsuccessful, or after years of successful function when the useful lifetime of the endosteal implant has finished.

The rare cases in which available bone width is less than 3.35 mm but available bone height is greater than 6 to 8 mm are not considered mainstream for any modality. In such cases, ridge height reduction may be performed to re-

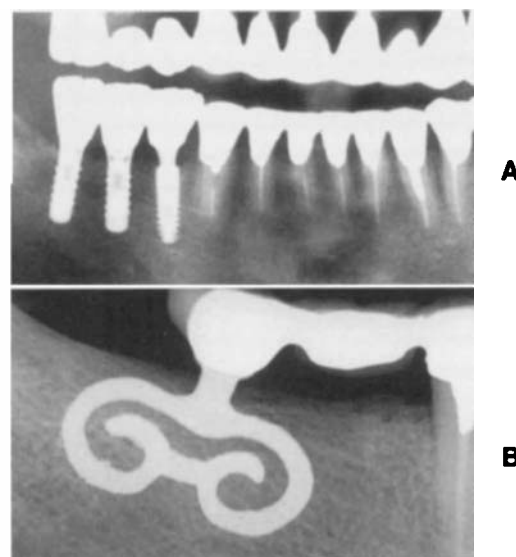


FIG. 16-2 ■ Similar deep available bone presentations treated with root form implants (A), and plate/blade form implants (B). (A, Courtesy Yasunori Hotta, Nagoya, Japan.)

move bone that is anticipated to resorb anyway to allow the placement of a subperiosteal implant, or bone augmentation may be undertaken to increase available bone width to the extent that a plate/blade form may be inserted. Of these two options, ridge height reduction and the use of a subperiosteal implant is considered closer to mainstream.

If the patient has a history of bruxism, or if for any reason the anticipated functional load may allow neither long, shallow plate/blade forms nor a subperiosteal implant to function successfully long-term within physiologic limits of health, the use of either may be questionable. In the maxilla, intramucosal inserts to improve retention and stability of a maxillary denture may be an option worth considering. An intramucosal insert teaching case is presented in Chapter 20.

Overlap Between the Root Form and Plate/Blade Form Modalities

General Considerations. Cases that present with sufficient available bone for insertion of root form implants can also be treated using plate/blade form implants (Fig. 16-2). Numerous clinical considerations help guide the practitioner to determine which modality should be used in such cases.

In addition to weighing all the clinical pros and cons of each modality for any given case, one must also consider that the practitioner's comfort and familiarity with a particular modality and system contribute greatly to successful treatment. The appropriate question is not, "Which implant is best?" The appropriate question is, "Which implant works best in my hands?" Although it is important not to

use exclusively the implant modality with which one is most comfortable at the expense of using a more appropriate modality when it is indicated, comfort and familiarity with a modality and/or system is a valid and important factor in diagnosing overlap cases.

Evaluate the Desirability and Availability of Natural Co-Abutments. A primary factor in helping the practitioner determine whether to use the root form or plate/blade form modality in an overlap case is the availability and desirability of using natural co-abutments. In mainstream cases, plate/blade forms should be used with natural co-abutments under a prosthesis, whereas root form implants should not be used with natural co-abutments. Therefore, in mainstream overlap cases, the availability and desirability of using natural co-abutments is a vital factor to guide the practitioner in deciding between these two modalities.

In cases in which the practitioner and/or the patient does not want to reduce the teeth adjacent to the edentulous area to be treated, the root form modality may be considered a superior option. However, in cases in which the additional support that could be afforded by the use of natural co-abutments may be necessary to ensure the long-term survival of the restoration, the plate/blade form option may be considered superior. One must evaluate whether the adjacent teeth require treatment unrelated to implant treatment, and if so, whether this treatment influences the desirability of using these teeth as co-abutments.

Reconciling Treatment Requirements With Patient Needs and Desires. The patient should help decide what treatment should be performed. The patient can and should provide the practitioner with information that directly bears on which modality should be chosen.

The information that the practitioner should elicit from the patient is related to the patient's experience. It is information that the patient clearly understands and can easily provide. In addition, intuition and analysis of the patient's history is important. Does the patient have any strong preferences regarding the total number of weeks that will be spent in treatment? Some patients want their treatment to be finished as quickly as possible, whereas others are not concerned with the timeframe. This consideration has a direct bearing on whether the practitioner should choose to use an osseointegrated or osteopreserved implant, because of their differing case sequencing requirements. Does the patient have a strong preference regarding the total number of treatment visits that will be required? Some patients have very flexible schedules, and can come in for treatment as often as the practitioner sees fit, whereas others have busy schedules that limit the number of treatment visits to which they can realistically commit. Is the patient's primary interest in the esthetic result, or is being able to function properly the primary goal? In most cases these options are not mutually exclusive, but the esthet-

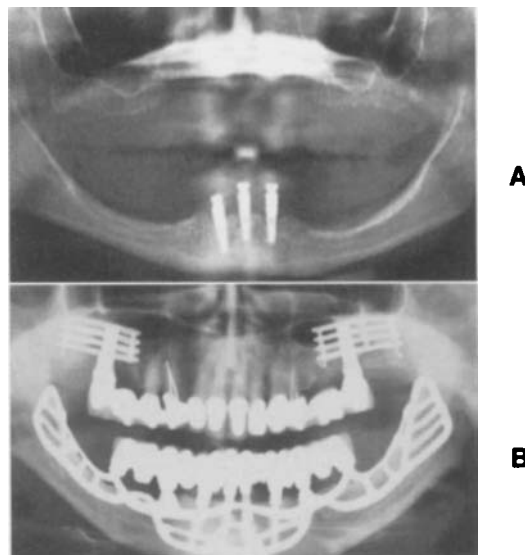


FIG. 16-3 ■ Similar available bone presentations treated with anterior root forms for overdenture restoration (A), and total subperiosteal implant (B). (A, Courtesy Edward Amet, Overland Park, Kan. B, Courtesy Walter Knouse, Lumberville, Pa.)

ics associated with each modality have differences that can affect one's decision. Can the patient reasonably be expected to perform sufficient home care following completion of the case? If not, a modality that is easier to maintain may be a superior option, whereas for a patient who can provide adequate home care this is not a determining factor.

Treatment Time and Expense. The amount of total elapsed time and number of visits for a typical mainstream case using each of the abutment-providing modalities, important considerations when choosing the modality in overlap cases, are discussed in each of the step-by-step treatment chapters. Another important consideration is cost. In general, the direct cost to the practitioner for implants and laboratory fees associated with the root form modality is higher than for the plate/blade form or subperiosteal implant modalities.

Overlap Between the Root Form and Subperiosteal Implant Modalities

There is no overlap between mainstream root form treatment and mainstream subperiosteal implant treatment. Mainstream subperiosteal treatment is always unilateral. In posterior edentulism cases, the available bone depth and width requirements for root form and subperiosteal implants are mutually exclusive. The only overlap between these two modalities is in cases of total mandibular edentulism, in which mainstream treatment can be performed using root forms anteriorly with an overdenture restoration, or a non-mainstream total subperiosteal implant can be inserted¹⁶ (Fig. 16-3).

INFORMED CONSENT—PRESENTING ALL TREATMENT OPTIONS

Obtaining informed consent is, of course, essential. However, informed consent does not merely mean having the patient sign a release form indicating awareness of the proposed treatment and its relative risks. The truly informed patient is educated by the practitioner regarding all of the treatment options or alternatives that apply to the case. Therefore, it is not sufficient, nor is it appropriate, for the practitioner to determine which implant modality to use in a case in which more than one is applicable, and then only inform the patient about the preselected option to obtain consent. It is the responsibility of the practitioner to explain to the patient that several courses of treatment may achieve the goal of providing fixed bridgework in the edentulous area. Each of these options should be discussed in some detail, covering points such as treatment time and expense. It is then the responsibility of the practitioner to make a sound recommendation. Only when the patient has heard all of the applicable treatment options and has agreed to the practitioner's recommended course of treatment, or has requested a modified treatment plan in consultation with the practitioner, has informed consent truly been obtained.

A more detailed discussion of informed consent is presented in Chapter 23.

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17 Diagnosis and Treatment of Reversible and Irreversible Implant Complications

REASONABLE EXPECTATIONS

Implant dentistry is currently being practiced in an atmosphere of enthusiasm and optimism, because our knowledge and ability to provide service to our patients has expanded so greatly in such a short period. This enthusiasm may lead to unrealistic expectations about prognosis. Survival rates drawn from ideal patient populations participating in prospective, serial, and retrospective clinical trials are too often quoted to patients, whose individual cases may not be analogous to those in study protocols.

The complications one will observe long-term after the treatment of mainstream cases are few, and rarely severe. However, although mainstream cases are the most predictable of all implant dentistry cases, complications do arise. Complications arise more often and more seriously in intermediate and advanced cases. Aging, changing health conditions, long-term wear and tear, poor home care, and inadequate professional maintenance all contribute.¹⁻³ In this regard, long-term complications in implant dentistry have the same etiology as periodontic, prosthodontic, and endodontic complications.

When presenting an implant dentistry treatment plan, it is important for the patient to understand that the vagaries of health represent an important variable influencing prognosis. Even if 95% of cases such as that presented by the patient survive longer than 10 years, this particular case may be one of the 5% that does not. Success cannot be guaranteed. What one can guarantee is to care, to do one's best, and to be there to help in the rare instance that something goes wrong. Patients appreciate and benefit from straight talk.

Basic Policy in the Treatment of Troubled and Failing Implants

Some single-modality practitioners tend to remove implants of any modality other than the one they favor in the presence of a complication, whether reversible or irreversible, and even sometimes when the implant is functioning and healthy. At the same time, they spare no effort to preserve implants of a modality they do favor, whatever the complications observed. This approach requires reevaluation. It is rare that an implant exhibiting complications cannot be treated, often in the same manner in which one would treat similar complications related to teeth. Implants that can be maintained with conservative treatment of complications should be preserved. At the same time, if one determines that an implant is truly failing, the best policy is to remove it as early as possible. This too is similar to the way that one treats complications related to teeth. The over-retained failing natural tooth is a prime cause of alveolar ridge bone loss. As a general rule, failing implants cause less bone loss than do failing teeth. Failing implants should be removed as early as possible, but first one must be sure that the trouble is irreversible. Always treat troubled implants conservatively in an attempt to maintain them. Most complications are reversible.⁴

In this chapter, an implant referred to as *troubled* exhibits reversible complications, and an implant referred to as *failing* exhibits irreversible complications.

Clinical Decisions

Over time, every dental implant practitioner must treat complications that arise in cases they or others have

treated. However, such complications are observed only rarely in a properly diagnosed mainstream case. In general, the practitioner who performed the initial treatment can approach such complications with a degree of comfort, because of familiarity with the modality and with the particular case at hand. However, cases treated by others that present with complications warrant special consideration. Is the practitioner able to treat and maintain the case? Is the complication reversible or irreversible? If the practitioner is in doubt about these questions, the case should be referred to a more experienced practitioner. A practitioner who exclusively treats mainstream cases may not be able to treat severe complications related to intermediate and advanced cases treated by another practitioner. Similarly, a single-modality practitioner may not be able to treat reversible complications related to an implant modality with which he or she is not familiar. Performing multimodal implant dentistry allows the practitioner to evaluate and treat a broader range of patients who present with complications, which in turn tends to increase one's referral base.

CONSERVATIVE TREATMENT FOR MINOR COMPLICATIONS

Minor complications are reversible. Their etiology and treatment are very similar to those related to teeth. Peri-implant problems, crestal bone loss, food impaction, poor occlusion, an inadequately designed restoration, breakage, or complications related to insufficient hygiene or poor patient habits can be treated as though they were related to teeth. Treatment of such minor complications includes gingival therapy such as gingivectomy, flaps, curettage, occlusal adjustment, dietary advice, and prosthesis modification, replacement, or repair. Treatment may include splinting or the addition of more abutments to compensate for under-engineering, and always includes instruction regarding immaculate home care coupled with routine professional maintenance.

The body's response to gentle, thorough treatment tends to be excellent. Time and again, one observes cases that function well for many years following appropriate conservative treatment of a complication.

Among the abutment-providing modalities, conservative treatment is least often required for plate/blade forms.^{5,6} Root forms also tend to show a relatively low incidence of complication. Loose screws, fractured screws, fractured implants, and broken solder joints are observed in only a very small percentage of cases.⁷⁻⁹ Although unilateral subperiosteal implants have long-term survival rates comparable to the endosteal modalities, they exhibit a greater incidence of reversible complications.¹⁰⁻¹³ However, most unilateral subperiosteal implants are easily maintained. Sometimes, conservative treatment is frequently required over the course of a few years, and then the case stabilizes, with no complications being observed for the next several years.^{14,15} In time, as with all other areas of practice, treatment of minor complications related to implant dentistry becomes a routine part of practice. Fully informed

patients, because of the great benefits afforded by implant dentistry, most often accept complications and their treatment with equanimity.

AGGRESSIVE TREATMENT FOR MORE SERIOUS COMPLICATIONS

Serious reversible complications require more experience and training to treat successfully. Treatment of such complications includes major peri-implant surgery, bone augmentation,¹⁶ gingival grafting, removal of a portion of a plate/blade form implant, removal of some struts or a portion of a subperiosteal implant, debridement of exposed threads of a root form implant, complex restorative retreatment, and sometimes, long-term antibiotic or other pharmaceutical therapies.¹⁷ When required, consultation or referral to a more experienced practitioner is advised.

TREATMENT OF FAILING IMPLANTS

A failing implant should be removed as soon as it is determined that its complications are irreversible. The considerations when removing implants of each of the three abutment-providing modalities are different, and these differences are important. The removal techniques are discussed separately for each. It is important to note that knowledge of removal techniques is not as widespread as knowledge of insertion, and that implant removal not in conformity with recommended techniques results in further complications, some of iatrogenic etiology.

Removal of Failing Root Form Implants

When a sufficient amount of bone loss, inflammation, infection, pain, or mobility is observed, or when implant fracture occurs, a root form implant is removed. Antibiotic coverage is instituted preoperatively and continued postoperatively. If the failing implant is not functioning independently, it is isolated from its prosthesis. Local anesthetic is administered. Removal of a root form implant is akin to tooth removal. Counterclockwise rotation, gentle bucco/labio-lingual luxation, and concomitant withdrawal occlusally most often unseats the implant. When a firmly seated implant must be removed, use of a coordinated trephine or XXL bur may be considered. The implant "socket" is curetted gently, and granulation tissue is removed. Portions of the socket approaching or encroaching on a sinus are curetted very gently, or tissue forceps are inserted to carefully remove granulation tissue, if present. The same is true of sockets approaching nerves, such as those in areas at or near the roof of the mandibular canal. Trim the gingival cuff as required, and undermine a small amount of soft tissue around the opening to enhance closure when suturing. Direct pressure controls bleeding. The same postoperative care provided when the implant was inserted is used now. Bone augmentation is not advised at the implant removal visit in inflamed

or infected areas but may be accomplished about 4 weeks later.

Removal of Failing Plate/Blade Form Implants

Isolate the implant from its overlying prosthesis following antibiotic coverage. Administer local anesthetic containing vasoconstrictor, which should include block and infiltration in the mandible, and infiltration alone in the maxilla. Also infiltrate along the crest of the ridge overlying the implant. Incise the crest, reflect the buccal and lingual flaps, and pass a scalpel blade between the lingual interface of the implant body and the lingual plate of bone of the implant socket. This will sever the fibers of the peri-implant ligament. While this is being done, feel whether the scalpel is stopped by bone plugs growing bucco/labio-lingually through implant vents. If these are present, as is generally the case, set an XXL bone bur into a high-speed airtor, angle the bur to pass along the same route the scalpel did, and cut through the bone plugs along the lingual surface of the implant body, using ample coolant. The entire implant is now moved bodily toward the lingual to disengage the remaining portion of each bone plug from within its vent. This is done by inserting a fine periosteal elevator at the buccal of the shoulder, between the buccal of the implant interface and the buccal plate of bone of the implant socket. The implant will be displaced lingually into the area created by the scalpel and bone bur. Then grasp the abutment or abutments, and lift the implant occlusally out of its socket.

As is the case following removal of a root form, the osteotomy is curetted to remove granulation and connective tissues, with caution in areas near the sinus or the roof of the mandibular canal. Trim the edges of the incision, and undermine enough tissue to ensure complete closure when suturing. Control bleeding with direct pressure. The same postoperative care employed when the implant was inserted is employed after removal. Bone augmentation is not advised at the time of implant removal in inflamed or infected areas.

Removal of a Failing Subperiosteal Implant

The procedure to remove a failing subperiosteal implant is aimed at reducing the incidence of iatrogenic complications. Recall that the subperiosteal implant functions in a state of periosteal integration. It is sheathed in dense collagenous connective tissue that constitutes the outer layer of the periosteum. In failing implants, one or more struts of the implant may have dehiscenced into the oral cavity. Isolate the implant from its overlying prosthesis.

Following administration of antibiotics and local anesthetic containing vasoconstrictor if it is not contraindicated, start by removing the exposed struts from the implant. This is best accomplished by severing them at each point at which they emerge into the oral cavity. Use a long, slim, flame-shaped coarse diamond in a high-speed airtor with ample coolant.

Next, incise the crest of the ridge on the same line along which the initial incision was made when the implant was first inserted. Remember that subperiosteal implants are used when available bone is insufficient for endosteal implants. Thus, subperiosteal implants lie closer to the mandibular canal and sinus. The system of removal dictates that these areas be protected. The inner layer of the periosteum should remain untouched. Only the crestal portion of the sheath is severed over each strut. When a scalpel blade touches the metal implant, it quickly dulls. Therefore, have several blades at hand, to work efficiently at all times. The implant should not and cannot be pulled or torn away. Patience and slow, gentle severing of the sheath over the outer aspect of every strut is the key to success. Do not sever the sheath under the struts to ensure avoidance of landmarks. Infiltrate additional local anesthetic, if required.

When the implant is ultimately lifted out of its severed sheath, do not pull on the residual fibrous tissue. Use a tissue forceps to remove granulation tissue gently. If an antral opening is observed, be sure to undermine the reflected tissue flap sufficiently to enable closure and suturing securely over the area. Trim tissue tags from the edges of the incision before suturing. Patience and gentle, thoughtful use of the scalpel and periosteal elevator are the keys to success. The same postoperative care provided when the implant was inserted is instituted. Augmentation is not advised in inflamed and infected areas at the implant removal visit.

After removal of a maxillary subperiosteal implant, the patient is advised not to blow his or her nose, to sneeze in a way that avoids undue antral pressure, and to avoid strenuous exercise for 2 weeks.

OTHER TREATMENT OPTIONS FOLLOWING REMOVAL

Conventional removable dentures are often used after implant removal, at least as a transitional option during the time required for complete healing. Following removal of endosteal implants, if the volume of available bone is insufficient for endosteal reimplantation, a subperiosteal implant may be considered. Sometimes, removable dentures are the final solution. In the maxilla, intramucosal inserts are often recommended to ensure greater retention and stability of a total or partial removable denture. Advanced implant techniques involving soft-tissue grafting, bone augmentation, ridge width expansion, and nerve repositioning may be useful after implant removal and healing, to create enough available bone for subsequent reimplantation. This may require one or more additional years of treatment, and only should be embarked upon with adequate training and after full and complete discussion leading to informed patient consent.

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18 Examples of Intermediate and Advanced Cases

Implantology has revolutionized dental diagnosis and treatment planning. One purpose of this book is to bring the entire profession into active participation in the field. Hence, the mainstream applications of professionally accepted implant modalities have been taught in step-by-step teaching cases. These mainstream cases are the most predictable, most standardized, and simplest of the cases encountered in implant dentistry. They are the way to begin.

This chapter focuses on the state of the art. It highlights great accomplishments that can be performed in implant dentistry today. The cases illustrated in this chapter represent the results of an explosion of understanding that has occurred in only the past 3 decades. Note in reviewing the cases that they use various modalities. The diagnosis and treatment planning for these cases resulted from a combination of scientific, clinical, and patient-related considerations. One cannot view these cases and conclude that another treatment plan would clearly have been superior. More than one treatment plan may have been applicable for many of these intermediate and advanced cases, yet each has succeeded as treated.

The authors are grateful that many of the world's most prominent dental implant practitioners contributed examples of intermediate and advanced treatment for this chapter. We acknowledge their contributions, case by case, with our sincere appreciation.

The lessons to be learned herein are important. These intermediate and advanced cases represent the apex of implant dentistry achievement. Being able to render such treatment is the goal of many practitioners who begin with mainstream cases. It is also comforting to know that there are fellow practitioners who can be resources for learning, and to whom patients whom one cannot or may not wish to treat can be referred. One of the most important points

of this chapter is that there are very few patients in need who are beyond the scope of implant dentistry. Nearly everyone can benefit from this discipline. Almost every condition of partial or total edentulism, regardless of the extent of alveolar ridge resorption, can be treated by a practitioner who has appropriate training and experience. In each of the cases presented in this chapter, the probable conventional treatment that the patient would have undergone is given, to emphasize the profound benefits offered by implant dentistry. Patients formerly were evaluated, and their treatment plan formulated, based on available natural abutment support. Now, additional new abutment support can be created where it would be optimal for restorative dentistry. This is the revolution in diagnosis and treatment planning afforded by implant dentistry.

Implant dentistry is an art and a science. The mainstream applications of professionally accepted modalities that are presented in the step-by-step teaching chapters by and large are not interpretive. They are predictable, and can be approached in almost the same way every time. This chapter highlights cases that pertain more to the art of implant dentistry. Determining the treatment plan for these severely compromised patients is a creative, interpretive, and individual process. Based on years of experience and knowledge of the procedures that tend to serve best in one's own hands, a treatment plan that goes well beyond the mainstream is formulated and executed. Graduating from exclusively performing mainstream implant dentistry to these more challenging cases, which require much creative problem solving, is extremely satisfying. Also, nothing is more satisfying than truly helping those patients in the most need, who are the very patients who require such treatment.

INTERMEDIATE AND ADVANCED CASES

■ CASE 1

Courtesy Jerry Soderstrom, Rapid City, South Dakota

Case as Presented

Female patient in her 50s. Edentulous maxilla. Except periodontally involved cuspids, edentulous mandible.

Probable Conventional Dentistry

Treatment Plan

Maxillary total removable denture. Mandibular total removable denture.

Implant Dentistry Treatment Plan

Implant

Ramus frame implant (Pacific Dental).

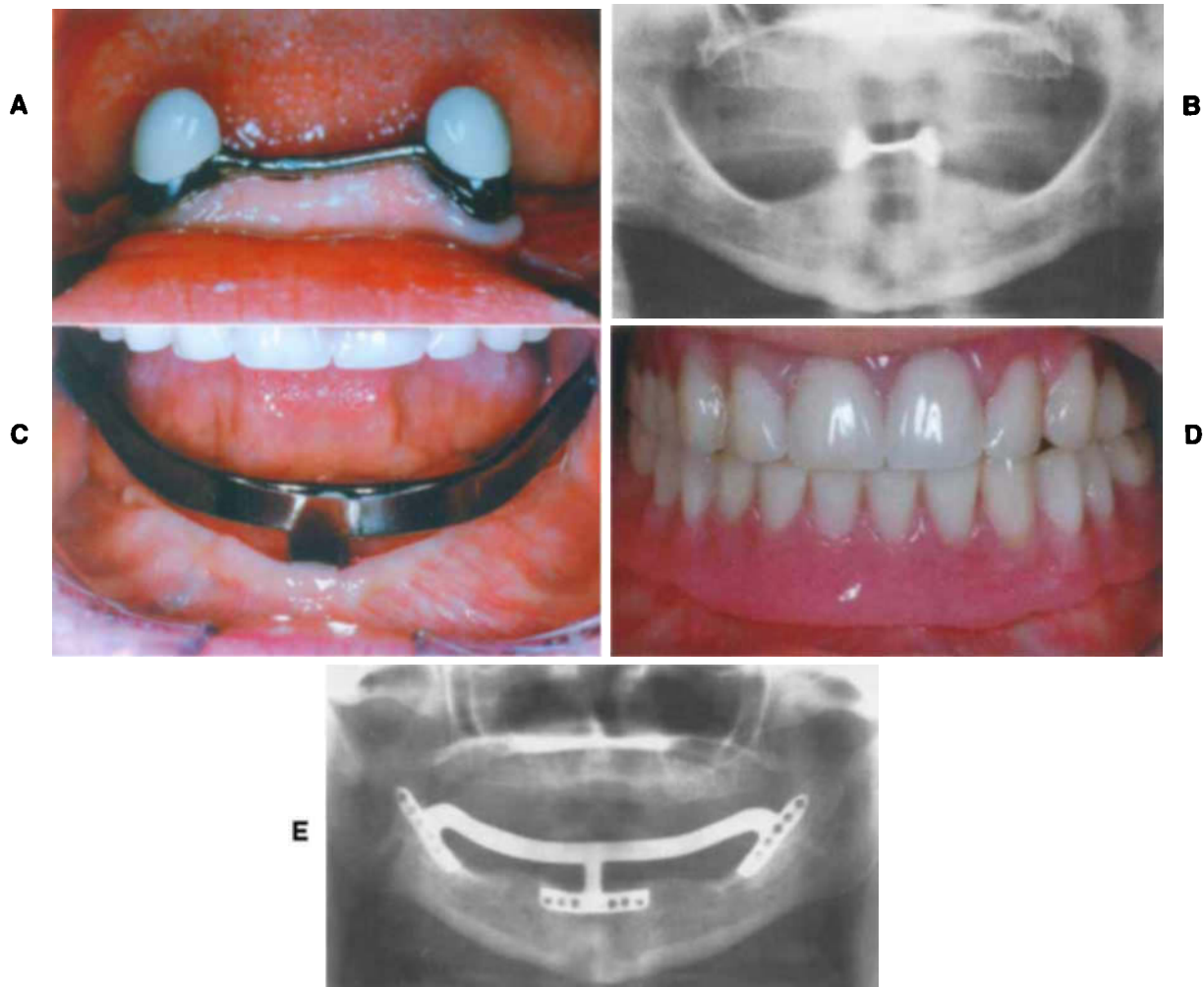
Prostheses

Maxillary total removable denture with future implant dentistry options. Mandibular semi-fixed overdenture.

Figures

- Preoperative mandible. Splinted cuspids with clip-bars (Fig. 18-1, A).
- Preoperative radiograph. Note available bone bilaterally under sinuses, and resorbed pre-maxilla. In mandible, periodontally involved cuspids, and bilateral shallow available bone over inferior alveolar canals (Fig. 18-1, B).
- Postoperative view of healed ramus frame positioning (Fig. 18-1, C).
- Postoperative view of prostheses (Fig. 18-1, D).
- Postoperative radiograph of ramus frame RA-3 implant in position (Fig. 18-1, E).

FIG. 18-1



■ CASE 2

Courtesy Edward A. Amet, Overland Park, Kansas

Case as Presented

Female patient in her 50s. Edentulous maxilla. Severe posterior mandibular resorption, adequate anterior available bone.

Probable Conventional Dentistry**Treatment Plan**

Maxillary total removable denture. Mandibular total removable denture.

Implant Dentistry Treatment Plan***Implants***

In mandible, five root form implants (Nobel Biocare/Steri-Oss).

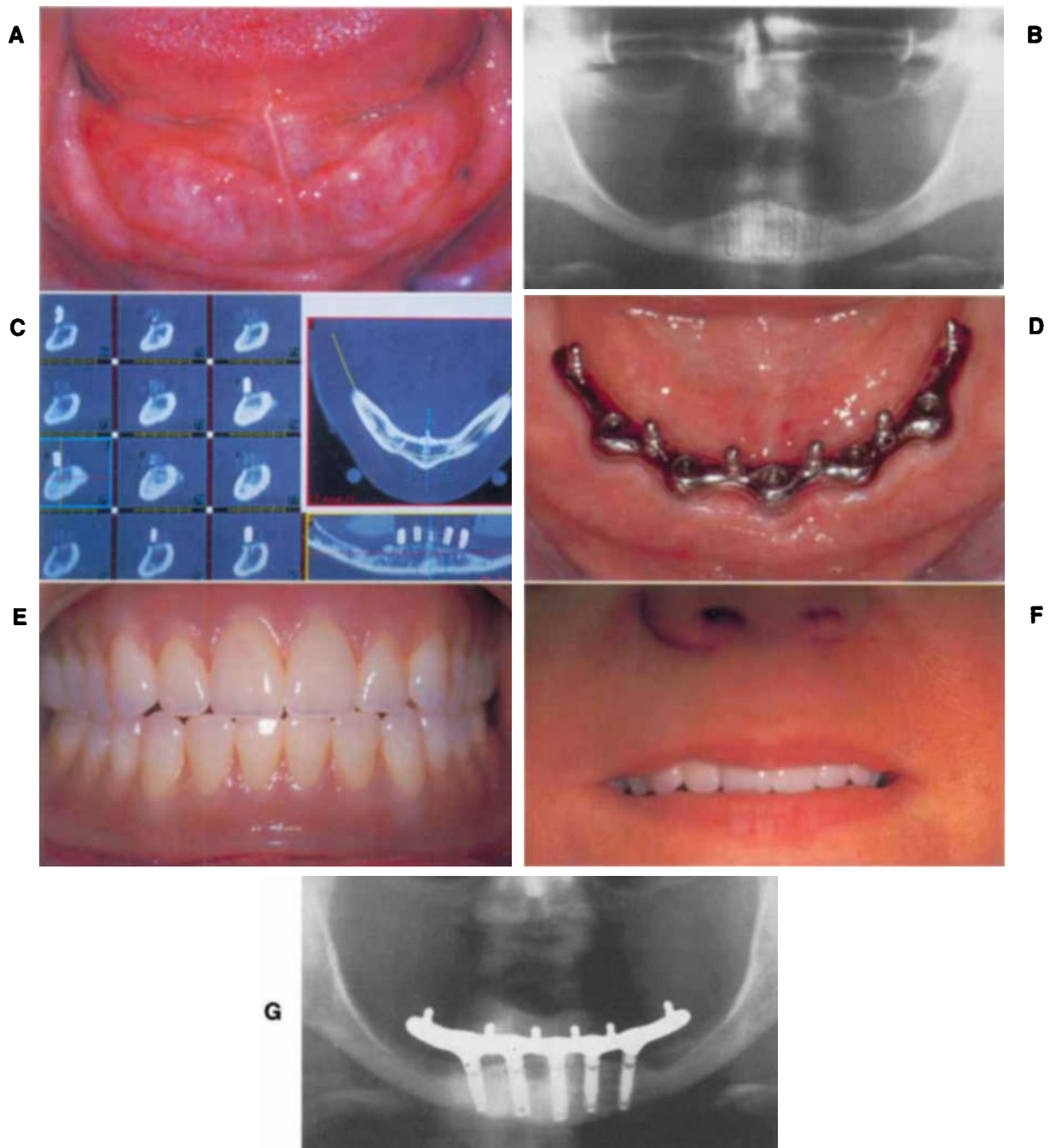
Prostheses

Mandibular implant splinting mechanism with provision for O-ring retained overdenture. Maxillary total removable denture.

Figures

- Preoperative view of edentulous mandible (Fig. 18-2, A).
- Preoperative radiograph. Note that only anterior segment has sufficient available bone for endosseous implants (Fig. 18-2, B).
- Preoperative segmented radiography to aid in planning implant positioning (Fig. 18-2, C).
- Postoperative view of mandible with splinting mechanism and O-ring extensions in place. Note quality of gingiva (Fig. 18-2, D).
- Prostheses in position (Fig. 18-2, E).
- Pleasing esthetic result (Fig. 18-2, F).
- Postoperative radiograph with splinting mechanism and O-ring extensions (Fig. 18-2, G).

FIG. 18-2



■ CASE 3**Case as Presented**

A female patient in her 60s. Maxillary arch presents with four teeth that can be retained. Edentulous mandible reveals adequate available bone.

Probable Conventional Dentistry**Treatment Plan**

In maxilla, fixed prosthesis from right second premolar to left cuspid, and partial removable denture. Or, removal of remaining maxillary teeth and total removable denture. In mandible, total removable denture.

Implant Dentistry Plan**Implants**

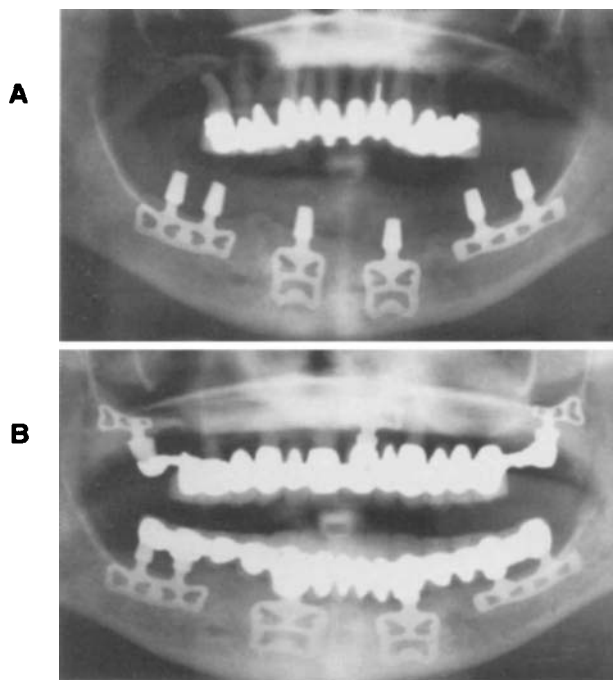
In maxilla, plate/blade form implant in each tuberosity, and one interdental plate/blade form implant (Oratronics). In mandible, four plate/blade form implants (Oratronics).

Prostheses

In maxilla, complete-arch porcelain-to-metal fixed prosthesis supported by plate/blade form implants and natural co-abutments. In mandible, complete-arch porcelain-to-metal fixed prosthesis, cement retained.

Figures

- Radiograph taken after insertions in mandible and before insertions in maxilla. Note available bone in mandible and maxillary tuberosities (Fig. 18-3, A).
- Postoperative radiograph. Note distal bar and coping to extend restoration to tuberosity implants. Distal tooth on each side of maxillary restoration is first molar (Fig. 18-3, B).

FIG. 18-3

■ CASE 4

Courtesy Walter Knouse, Lumberville, Pennsylvania

Case as Presented

Female patient in her 70s. Posterior maxillary edentulism, with eight satisfactory anterior teeth. Three remaining anterior mandibular teeth require removal. Resorbed mandibular alveolar ridges posteriorly.

Probable Conventional Dentistry

Treatment Plan

Maxillary partial removable denture. Mandibular total removable denture.

Implant Dentistry Treatment Plan

Bone Enhancement

Maxillary bilateral subantral augmentation to accommodate large size of planned plate forms. Augmented with demineralized freeze-dried bone, tricalcium phosphate, and Lambone.

Implants

Plate form implants (Omni) in posterior maxilla. Mandibular total subperiosteal implant.

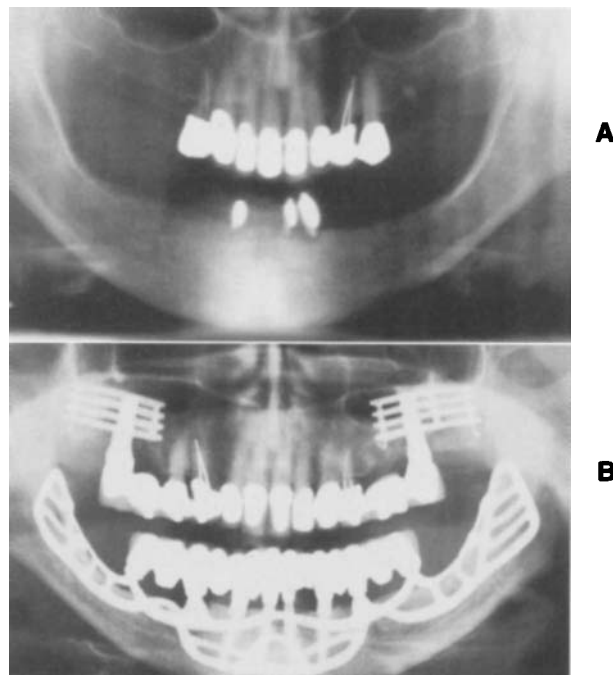
Prostheses

Maxillary partial-arch porcelain-to-metal fixed prostheses supported by implant and tooth abutments. Mandibular complete-arch porcelain-to-metal fixed prosthesis supported entirely by implant.

Figures

- Preoperative radiograph. Remaining mandibular teeth require removal (Fig. 18-4, A).
- Postoperative radiograph with implants and prostheses in position (Fig. 18-4, B).

FIG. 18-4



■ CASE 5

Courtesy Ralph Roberts, Rio Dell, California

Case as Presented

Female patient in her 60s. Edentulous maxilla, edentulous mandible, severely resorbed posteriorly.

Probable Conventional Dentistry**Treatment Plan**

Maxillary and mandibular total removable dentures.

Implant Dentistry Treatment Plan**Implant**

Ramus frame implant (Pacific Dental).

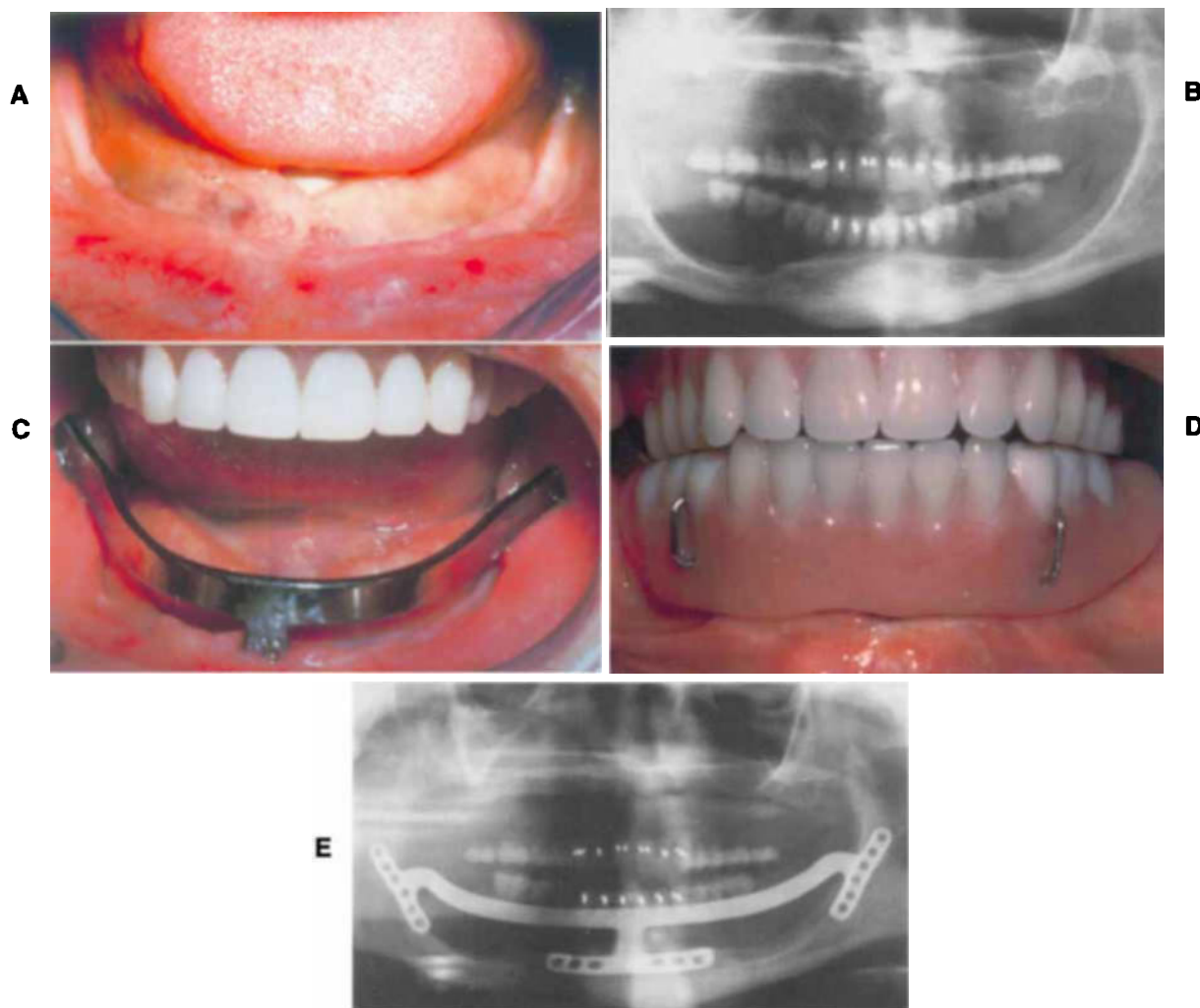
Prostheses

Maxillary total removable denture. Mandibular semi-fixed overdenture.

Figures

- Preoperative view of edentulous mandible. Note alveolar ridges positioned inferior to floor of mouth and raised tongue (Fig. 18-5, A).
- Preoperative radiograph. Note minimal posterior available bone (Fig 18-5, B).
- Postoperative view of mandible with healed implant in position (Fig. 18-5, C).
- Postoperative view of mandibular semi-fixed overdenture. Note locking mechanism (Fig. 18-5, D).
- Postoperative radiograph showing ramus frame implant in position (Fig. 18-5, E).

FIG. 18-5



■ CASE 6

Courtesy Keisuke Wada, Nagoya, Japan

Case as Presented

Male patient in his teens with congenital ectodermal dysplasia. Totally edentulous except for one tooth. Severely resorbed ridges, xerostomia. Unable to wear lower denture.

Probable Conventional Dentistry**Treatment Plan**

Serial fabrication of maxillary and mandibular total removable dentures to accommodate growth pattern. Prognosis poor.

Implant Dentistry Treatment Plan**Implants**

Five screw-type root form implants (Nobel Biocare) in anterior mandible.

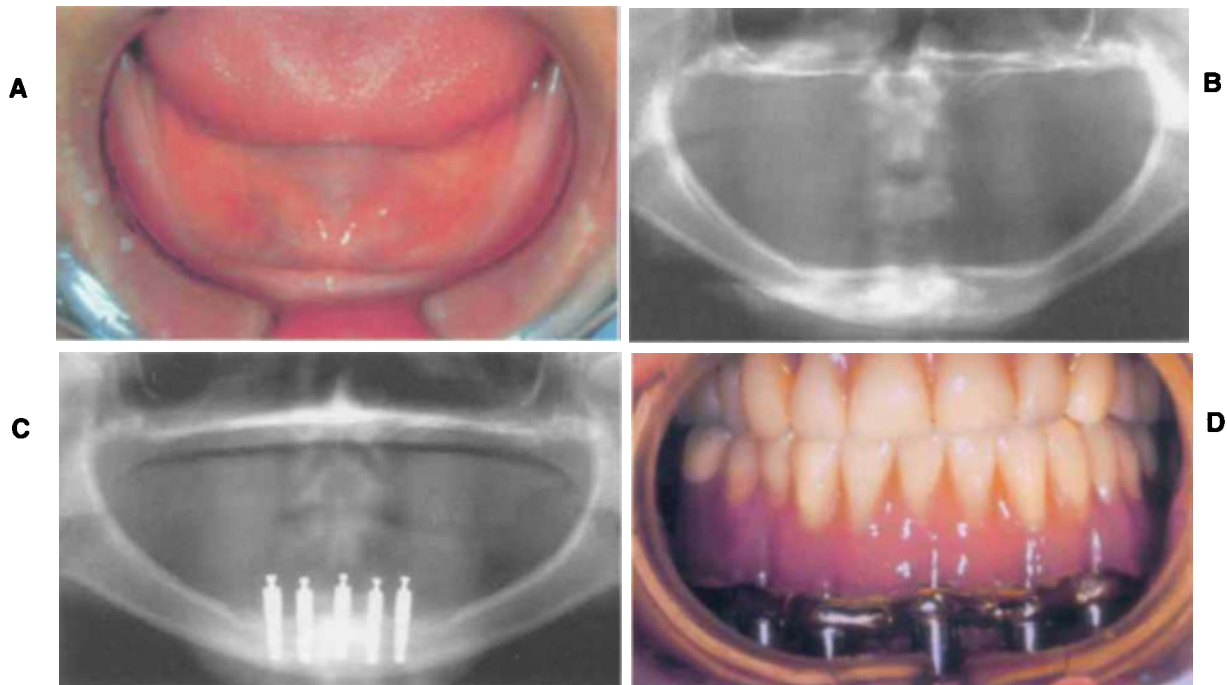
Prostheses

Maxillary total removable denture. In mandible, implant splinting mechanism with provision for screw-retained fixed overdenture.

Figures

- Preoperative view of mandible. Note severe resorption (Fig. 18-6, A).
- Preoperative radiograph. Note severely resorbed ridges in entire maxilla and posterior mandible (Fig. 18-6, B).
- Postoperative radiograph. Note five screw-type root forms inserted into anterior mandible (Fig. 18-6, C).
- Postoperative view of implants, splinting mechanism, and mandibular screw-retained fixed overdenture. Maxillary total removable denture (Fig. 18-6, D).

FIG. 18-6



■ CASE 7

Courtesy Katsura Omura, Kyoto, Japan

Case as Presented

Male patient in his 50s. Edentulous mandible. Maxillary teeth present from right first premolar through left second premolar.

Probable Conventional Dentistry**Treatment Plan**

Maxillary partial removable denture. Mandibular total removable denture.

Implant Dentistry Treatment Plan**Implants**

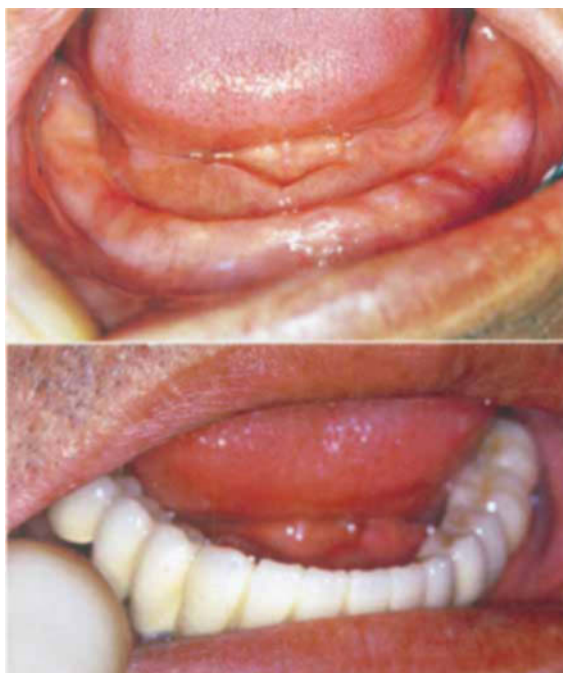
Five plate/blade form implants (Oratronics).

Prosthesis

Mandibular porcelain-to-metal 14-unit complete-arch fixed prosthesis.

Figures

- Preoperative view of edentulous mandible (Fig. 18-7, A).
- Preoperative radiograph (Fig. 18-7, B).
- Postoperative view of completed prosthesis inserted (Fig. 18-7, C).
- Postoperative radiograph (Fig. 18-7, D).



C

D

■ CASE 8

Courtesy Eiichi Kojima, Tokyo, Japan

Case as Presented

Edentulous maxilla. Edentulous mandible.

Probable Conventional Dentistry Treatment Plan

Maxillary and mandibular total removable dentures.

Implant Dentistry Treatment Plan**Implant**

Mandibular total subperiosteal implant.

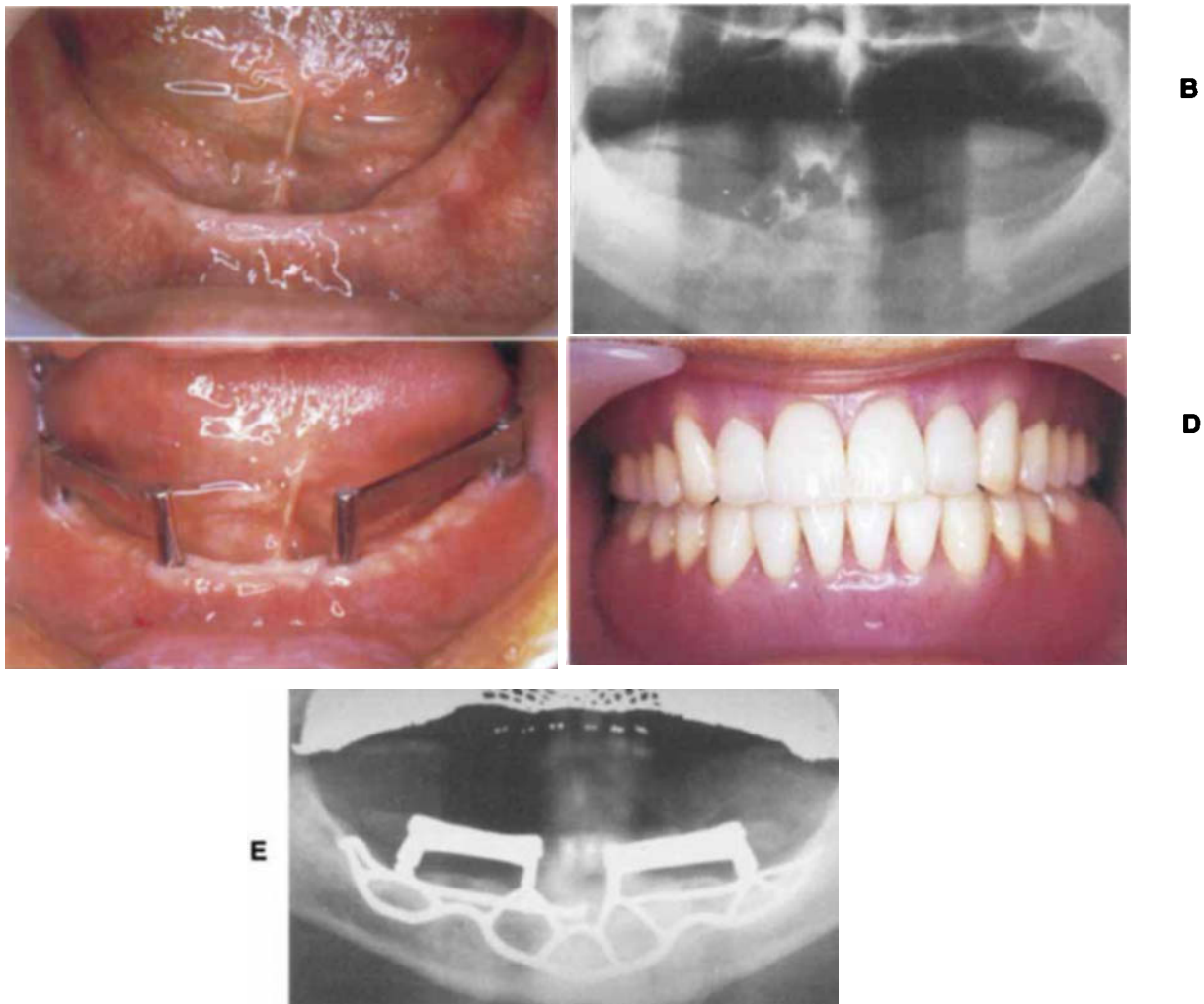
Prostheses

Maxillary total removable denture. Mandibular semi-fixed overdenture.

Figures

- Preoperative view of mandible. Note band of attached gingiva (Fig. 18-8, A).
- Preoperative radiograph (Fig. 18-8, B).
- Postoperative view of mandible. Inserted implant with well-healed pergingival sites (Fig. 18-8, C).
- Postoperative view of completed prostheses in position (Fig. 18-8, D).
- Postoperative radiograph (Fig. 18-8, E).

FIG. 18-8



■ CASE 9

Case as Presented

Female patient in her 60s. Edentulous maxilla. Edentulous mandible.

Probable Conventional Dentistry**Treatment Plan**

Maxillary total removable denture. Mandibular total removable denture.

Implant Dentistry Treatment Plan**Implants**

Mandibular plate/blade form implants (Oratronics), single abutment in right and left posterior, double abutment between mental foramina.

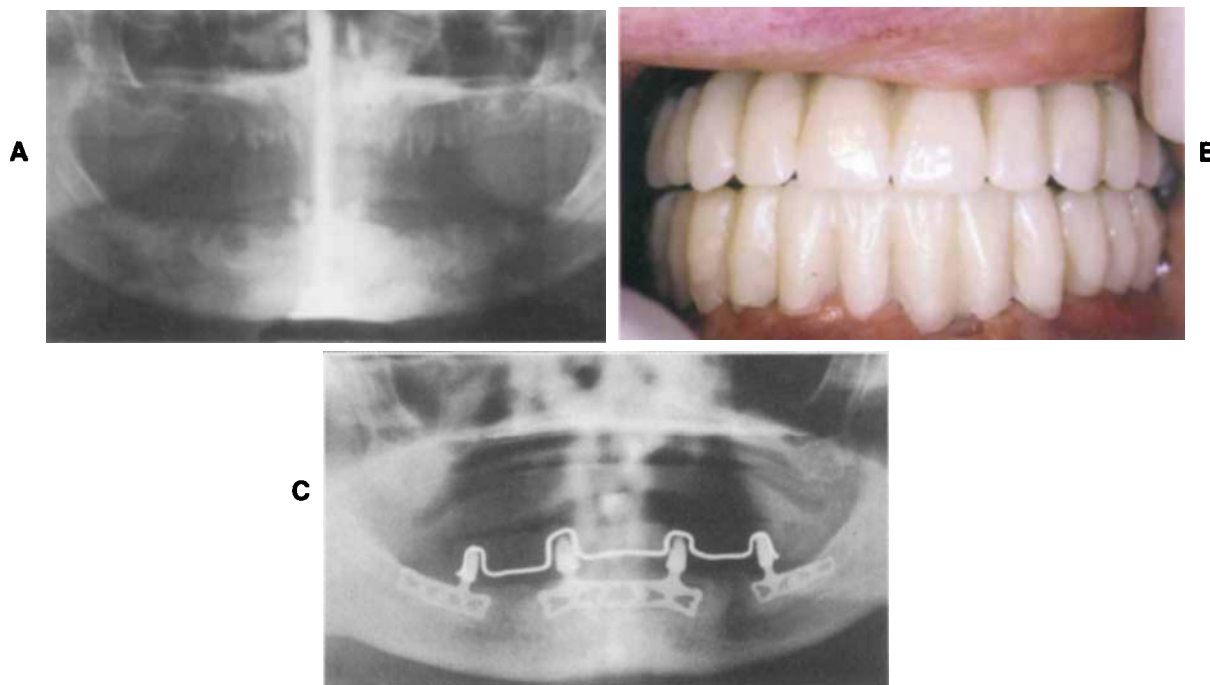
Prostheses

Complete-arch reinforced acrylic fixed prosthesis.

Figures

- Preoperative radiograph (Fig. 18-9, A).
- Postoperative view of mandibular complete-arch fixed prosthesis. Note ridge lapping (Fig. 18-9, B).
- Postoperative radiograph. Note reinforcing metal rod baked within complete-arch acrylic fixed prosthesis (Fig. 18-9, C).

FIG. 18-9



■ CASE 10

Courtesy Jerry Soderstrom, Rapid City, South Dakota

Case as Presented

Female patient in her 70s. Edentulous maxilla. Edentulous mandible.

Probable Conventional Dentistry Treatment Plan

Maxillary total removable denture. Mandibular total removable denture.

Implant Dentistry Treatment Plan

Implant

Custom-made mandibular tripodal subperiosteal, fabricated on model created with aid of computerized axial tomography (CAT).

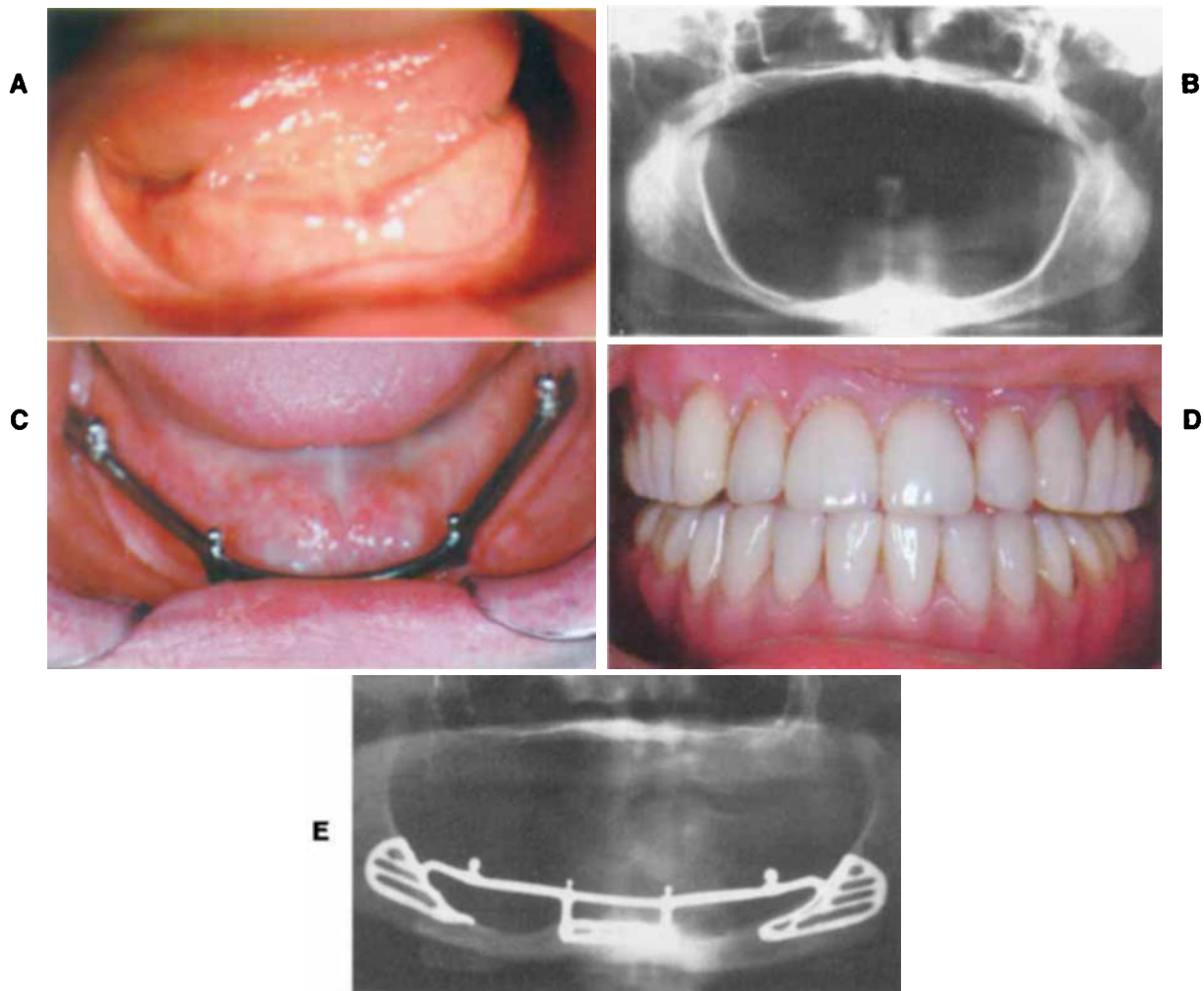
Prostheses

Maxillary total removable denture with future implant dentistry options. Mandibular semi-fixed overdenture.

Figures

- Preoperative edentulous mandible. Note relative positions of tongue, tissues of floor of mouth, and clinical ridge crest (Fig. 18-10, A).
- Preoperative radiograph. Severe alveolar ridge atrophy (Fig. 18-10, B).
- Postoperative view of healed tripodal subperiosteal positioning (Fig. 18-10, C).
- Postoperative view of prostheses (Fig. 18-10, D).
- Postoperative radiograph. Classic placement of mandibular tripodal subperiosteal implant (Fig. 18-10, E).

FIG. 18-10



■ CASE 11

Courtesy Edward M. Amet, Overland Park, Kansas

Case as Presented

Female patient in her 50s. Edentulous maxilla with adequate available bone. Edentulous mandible with severe resorption.

Probable Conventional Dentistry**Treatment Plan**

Maxillary total removable denture. Mandibular total removable denture.

Implant Dentistry Treatment Plan**Implant**

CAD/CAM-generated tripodal subperiosteal in mandible.

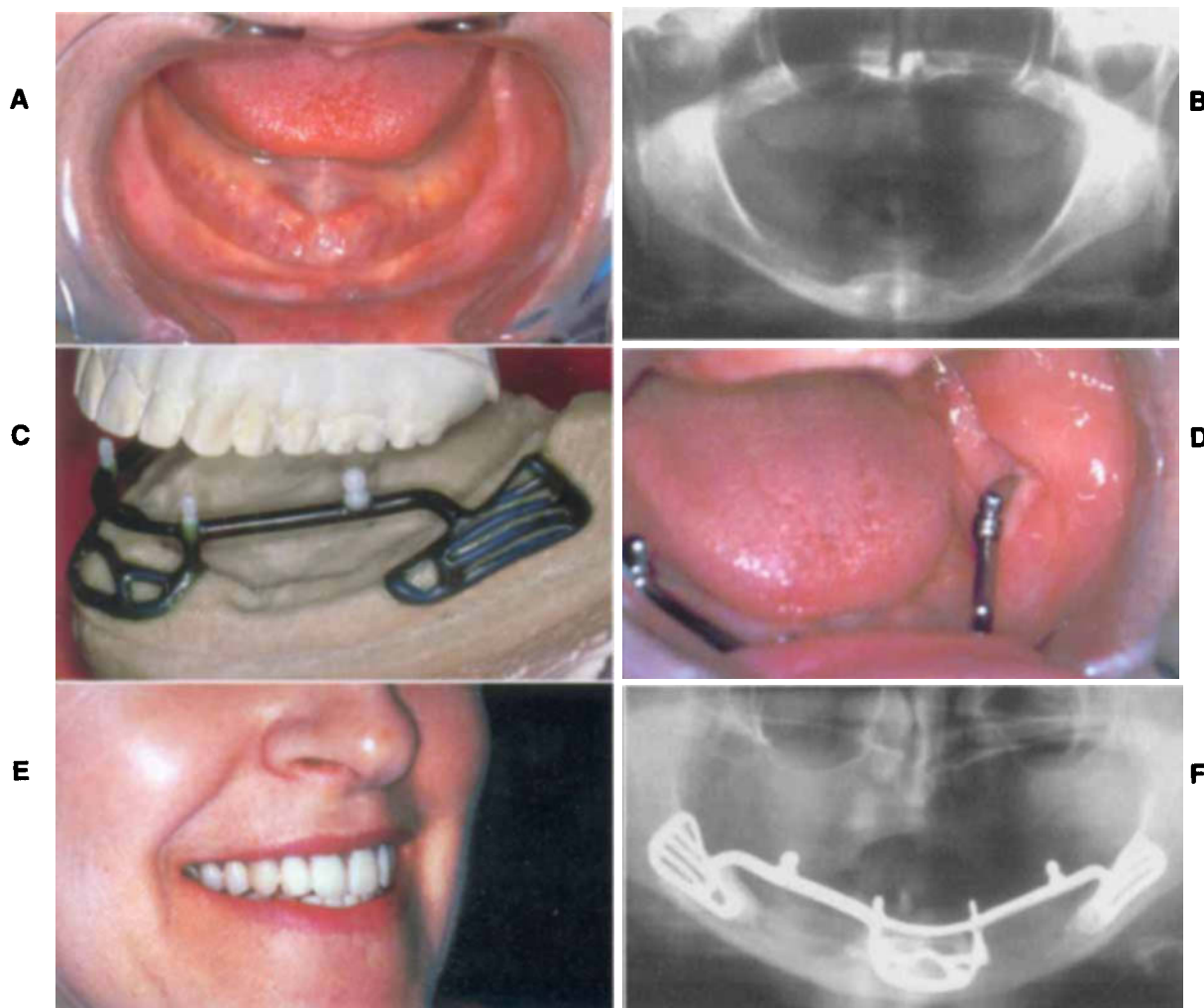
Prostheses

Maxillary total removable denture. Mandibular semi-fixed overdenture.

Figures

- Preoperative view of edentulous mandible (Fig. 18-11, A).
- Preoperative radiograph. Note severe mandibular atrophy (Fig. 18-11, B).
- Preoperative view of laboratory wax-up of tripodal subperiosteal on computer-generated model (Fig. 18-11, C).
- Postoperative view of healed implant in position. Note keratinized gingiva around left posterior pergingival site (Fig. 18-11, D).
- Postoperative view of esthetics (Fig. 18-11, E).
- Postoperative radiograph of tripodal subperiosteal in position (Fig. 18-11, F).

FIG. 18-11



■ CASE 12

Courtesy Ralph Roberts, Rio Dell, California

Case as Presented

Female patient in her 60s. Edentulous maxilla. Edentulous mandible with adequate available bone.

Probable Conventional Dentistry**Treatment Plan**

Maxillary total removable denture. Mandibular total removable denture.

Implant Dentistry Treatment Plan**Implants**

Double-abutment plate/blade form implant in anterior mandible and two ramus blades (Pacific Dental).

Prostheses

Maxillary total removable denture. Mandibular complete-arch porcelain-to-metal fixed prosthesis.

Figures

- Preoperative view of edentulous mandible. Note anatomy of ridge (Fig. 18-12, A).
- Preoperative radiograph. Note adequate available bone in mandible, marginal available bone in maxilla (Fig. 18-12, B).
- Postoperative view of mandible showing complete-arch porcelain-to-metal fixed restoration in position (Fig. 18-12, C).
- Postoperative radiograph showing implants and final restoration in place (Fig. 18-12, D).

FIG. 18-12



■ CASE 13

Courtesy Walter Knouse, Lumberville, Pennsylvania

Case as Presented

Female patient in her 60s. Edentulous maxilla. Mandible previously treated with five screw-type root forms and fixed prosthesis with distal cantilevering on each side, currently irreversibly compromised.

Probable Conventional Dentistry**Treatment Plan**

Maxillary total removable denture. Removal of all mandibular implants, and following healing, a total removable denture.

Implant Dentistry Treatment Plan**Implant**

Mandibular tripodal subperiosteal implant.

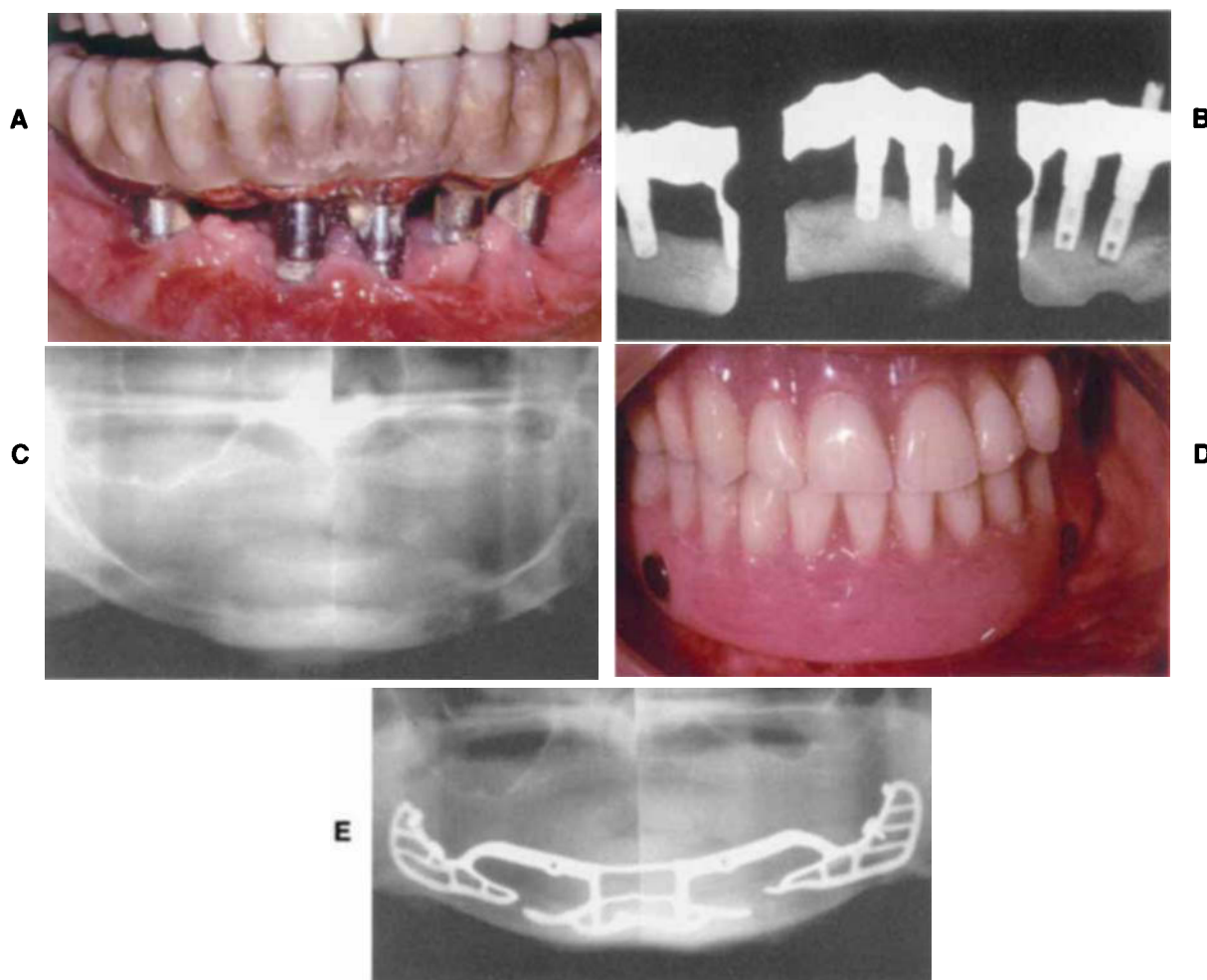
Prostheses

Maxillary total removable denture. Mandibular semi-fixed overdenture.

Figures

- Preoperative view showing compromised previously placed implants and prosthesis. Note extremely poor hygiene (Fig. 18-13, A).
- Preoperative radiographs before implant removals (Fig. 18-13, B).
- Preoperative radiograph following implant removals and healing (Fig. 18-13, C).
- Postoperative view of final prostheses in position. Note locking device on mandibular semi-fixed denture (Fig. 18-13, D).
- Postoperative radiograph showing tripodal subperiosteal in position. Note positions of screw retention (Fig. 18-13, E).

FIG. 18-13



■ CASE 14

Courtesy Neal B. Gittleman (restoration) and R. Kent Stobaugh (insertion), Houston, Texas

Case as Presented

Female patient in her 40s. In maxilla, residual edentulous alveolar ridges were severely resorbed. Remaining teeth were periodontally involved. Mandible presented with pseudo-prognathism, and periodontal involvement of remaining teeth. Both arches contained ill-fitting dentures.

Probable Conventional Dentistry Treatment Plan

Removal of all remaining teeth. Fabrication of maxillary and mandibular total removable dentures.

Implant Dentistry Treatment Plan

Preliminary Procedures

Removal of all remaining teeth and alveoloplasty.

Bone Enhancement

Right maxillary subantral augmentation and pre-maxilla symphyseal onlay bone graft.

Implants

Maxilla implanted with six screw-type root form implants (Nobel Biocare/Steri-Oss). Mandible implanted with five screw-type root form implants (Nobel Biocare/Steri-Oss).

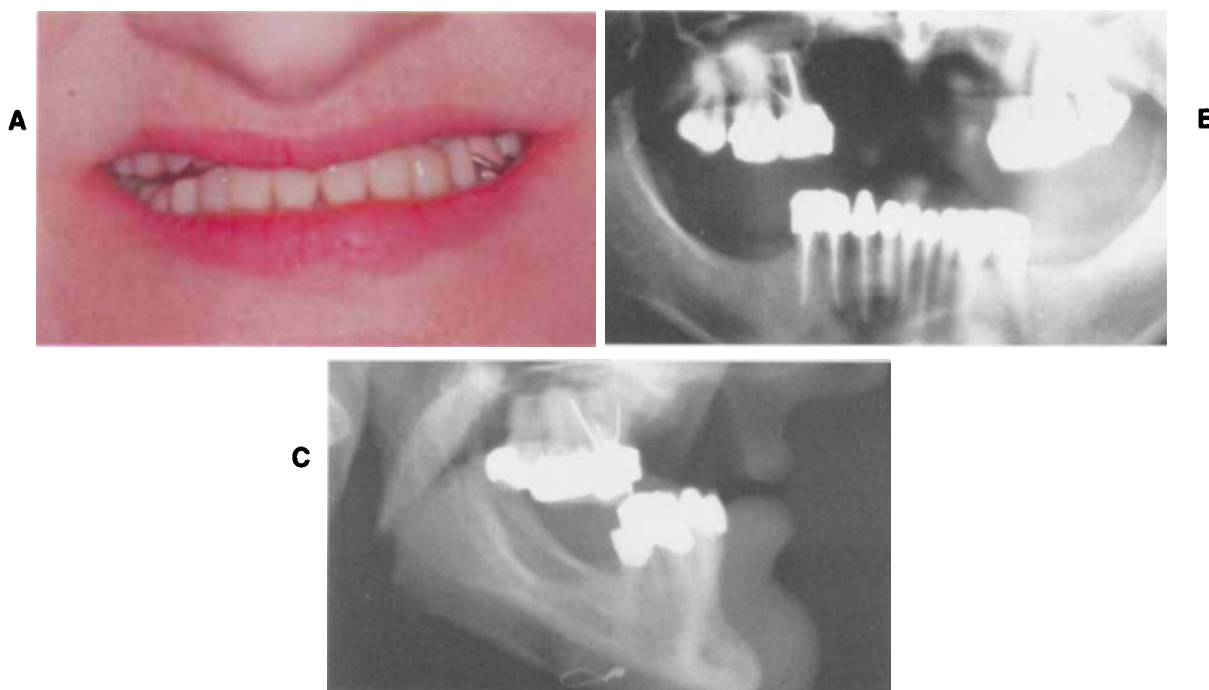
Prostheses

Maxillary implants splinted with incorporated retention mechanism for overdenture. Mandibular fixed screw-retained overdenture.

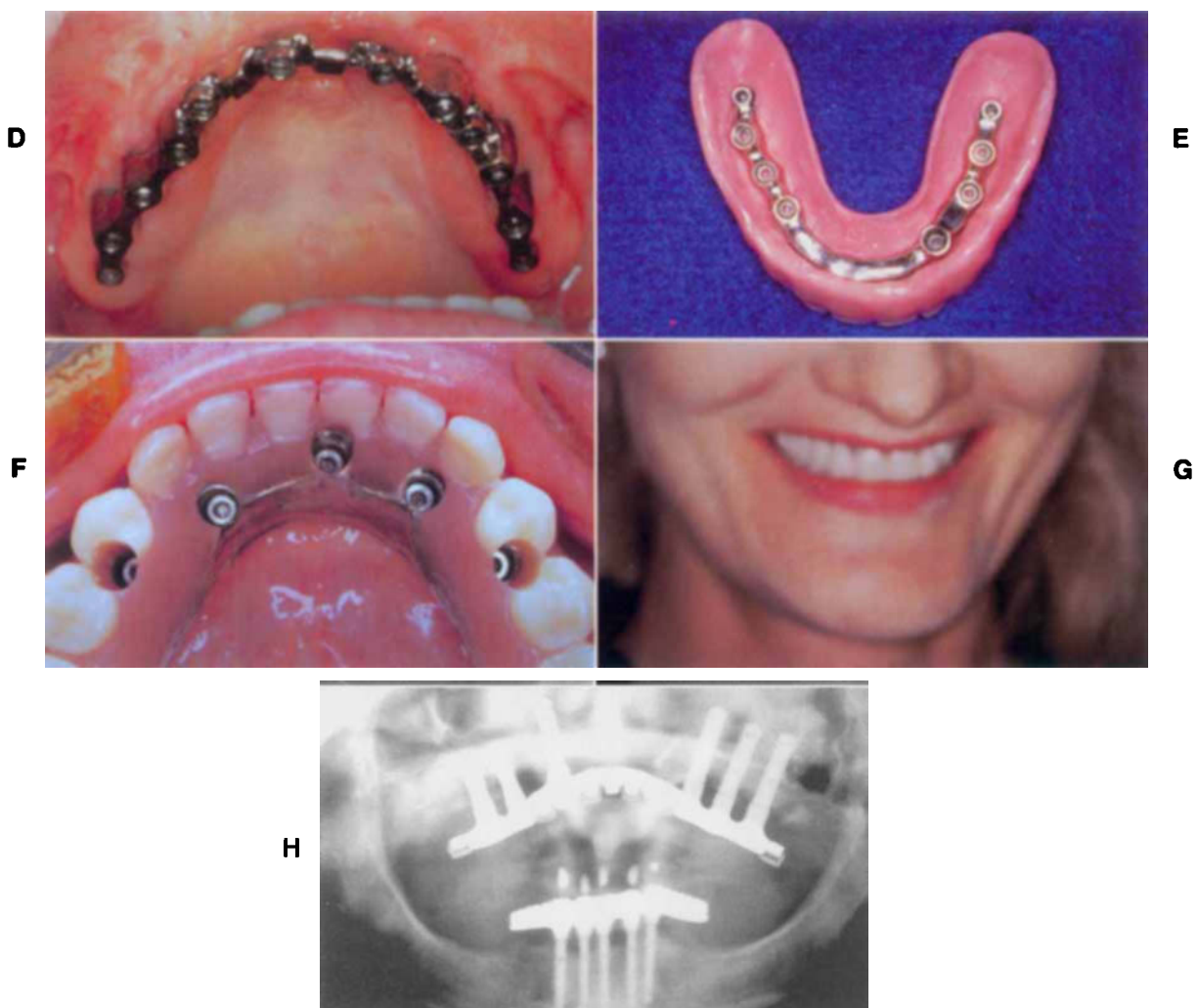
Figures

- Preoperative view of patient. Note anterior occlusion and prognathism (Fig. 18-14, A).
- Preoperative radiograph (Fig. 18-14, B).
- Preoperative lateral cephalometric radiograph. Note pseudo-prognathism (Fig. 18-14, C).

FIG. 18-14



- Postoperative view of maxilla with implant splint and incorporated retention mechanism in position (Fig. 18-14, *D*).
- View of maxillary overdenture—tissue surface (Fig. 18-14, *E*).
- Postoperative view of mandibular fixed screw-retained prosthesis (Fig. 18-14, *F*).
- Postoperative view of esthetic result (Fig. 18-14, *G*).
- Postoperative radiograph (Fig. 18-14, *H*).



■ CASE 15

Courtesy Jerry Soderstrom, Rapid City, South Dakota

Case as Presented

Male patient in his 50s. Edentulous maxilla. Partially edentulous mandible in right second premolar and molar area.

Probable Conventional Dentistry

Treatment Plan

Maxillary total removable denture. Mandibular partial removable denture.

Implant Dentistry Treatment Plan

Bone Enhancement

Maxillary anterior onlay bone graft and bilateral subantral augmentation.

Implants

Eleven root forms in maxilla, and two in mandible (Calcitek).

Prostheses

Maxillary 14-unit complete-arch splinted fixed prosthesis. Mandibular 3-unit splinted fixed prosthesis.

Figures

- Preoperative edentulous maxilla (Fig. 18-15, A).
- Preoperative radiograph. Severe maxillary alveolar bone resorption. Abundant right mandibular available bone (Fig. 18-15, B).
- Postoperative esthetics of maxillary fixed prosthesis (Fig. 18-15, C).
- Postoperative radiograph. Eleven well-placed and splinted root forms in maxilla. Note anterior onlay and subantral augmentations (Fig. 18-15, D).

FIG. 18-15



■ CASE 16

Courtesy Walter Knouse, Lumberville, Pennsylvania

Case as Presented

Following removal of two anterior teeth, maxilla was totally edentulous. Mandible cuspid and first premolar splinted on each side. Other posterior tooth roots on each side required removal.

Probable Conventional Dentistry

Treatment Plan

Maxillary total removable denture. Mandibular partial removable denture.

Implant Dentistry Treatment Plan

Implants

In anterior maxilla, six root form implants (Nobel Biocare/Steri-Oss). In anterior mandible, two root form implants (Nobel Biocare/Steri-Oss), and in posterior mandible, custom-made plate/blade form implant on each side.

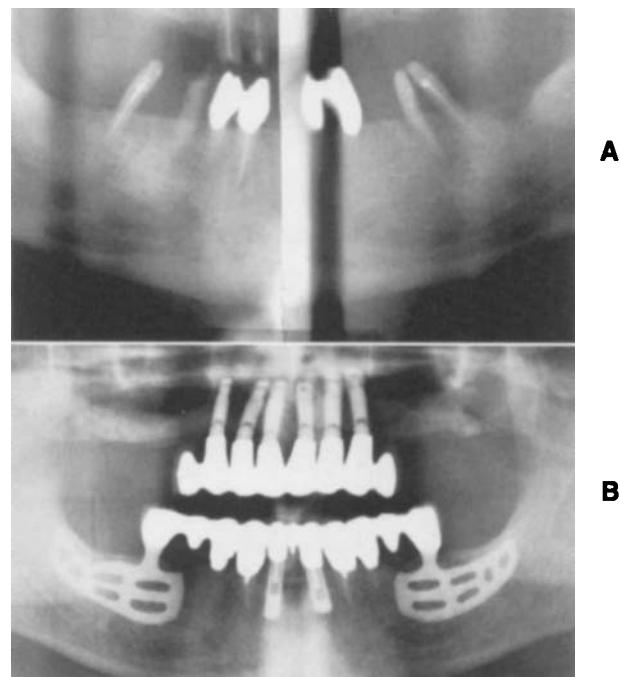
Prostheses

Two porcelain-to-metal fixed prostheses. Distal cantilever on each side of maxilla.

Figures

- Preoperative radiograph of mandible (Fig. 18-16, A).
- Postoperative radiograph showing variability of implant support with natural co-abutments (Fig. 18-16, B).

FIG. 18-16



■ CASE 17

Case as Presented

Male patient in his 70s. Edentulous maxilla with abundant available bone everywhere. Bilateral posterior edentulism in mandible with abundant available bone.

Probable Conventional Dentistry

Treatment Plan

Maxillary total removable denture. Mandibular partial removable denture.

Implant Dentistry Treatment Plan

Implants

In maxilla, four plate/blade form implants (Oratronics). In mandible, two plate/blade forms (Oratronics), one endodontic stabilizer for left lateral incisor (Oratronics).

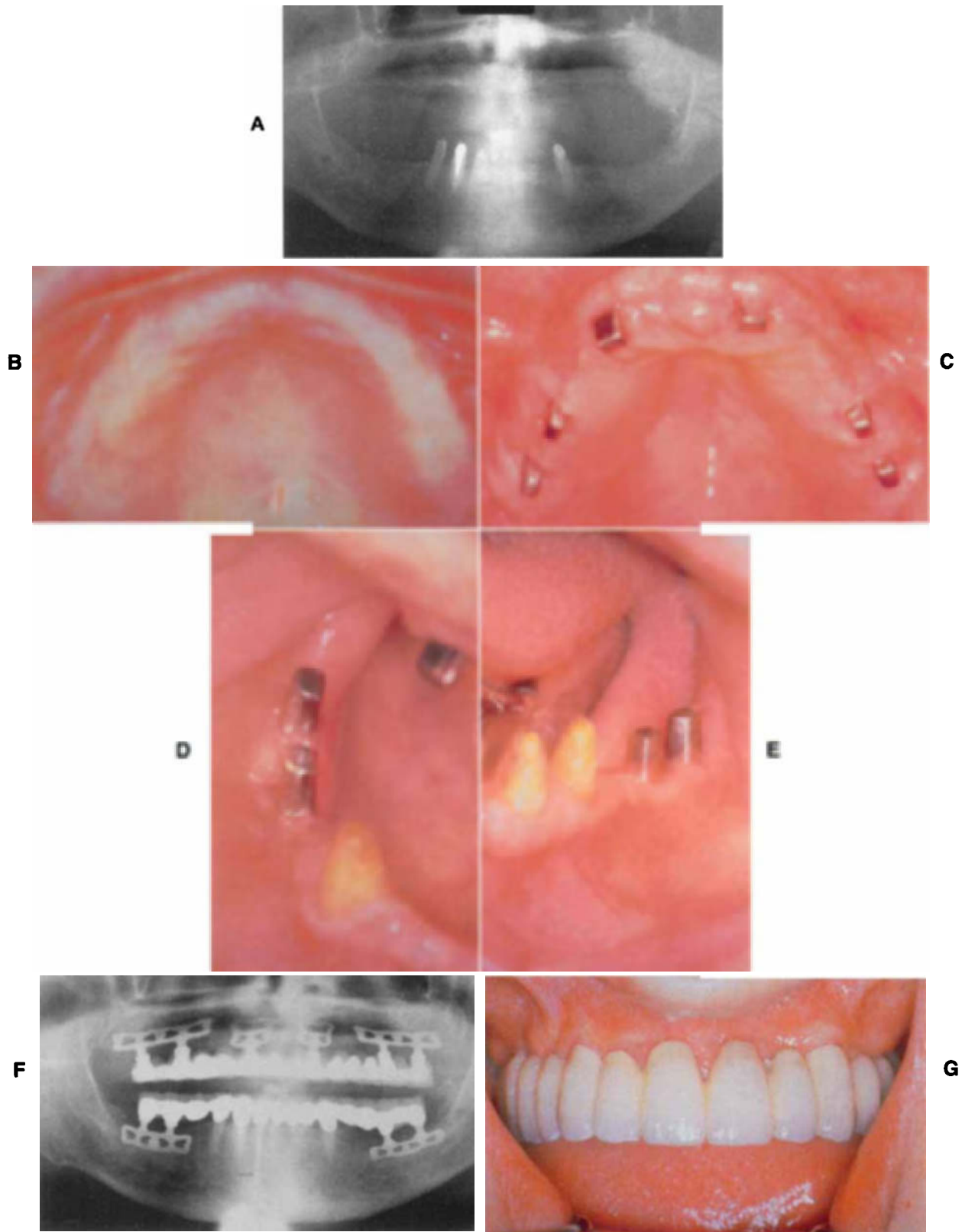
Prostheses

Maxillary complete-arch porcelain-to-metal fixed prosthesis. Mandibular complete-arch porcelain-to-metal fixed prosthesis supported by plate/blade form and natural co-abutments.

Figures

- Preoperative radiograph. Note abundant available bone in both arches (Fig. 18-17, A).
- Preoperative view of edentulous maxilla (Fig. 18-17, B).
- Postinsertion view of maxilla (Fig. 18-17, C).
- Postinsertion view of right mandible (Fig. 18-17, D).
- Postinsertion view of left mandible (Fig. 18-17, E).
- Postoperative radiograph. Note symmetry of plate/blade form positioning. Note endodontic stabilizer at tooth No. 23 (Fig. 18-17, F).
- Postoperative view of maxillary restoration (Fig. 18-17, G).

FIG. 18-17



■ CASE 18

Courtesy Keisuke Wada, Nagoya, Japan

Case as Presented

Female patient in her teens. Unilateral cleft lip and maxillary alveolus. Congenitally absent lateral incisor.

Probable Conventional Dentistry

Treatment Plan

Maxillary four-unit porcelain-to-metal fixed prosthesis, with adjacent cuspid and both central incisors as abutments and lateral incisor pontic.

Implant Dentistry Treatment Plan

Implant

Augmented lateral incisor area implanted with screw-type root form implant (Nobel Biocare).

Augmentation

Autogenous bone from mandibular symphysis.

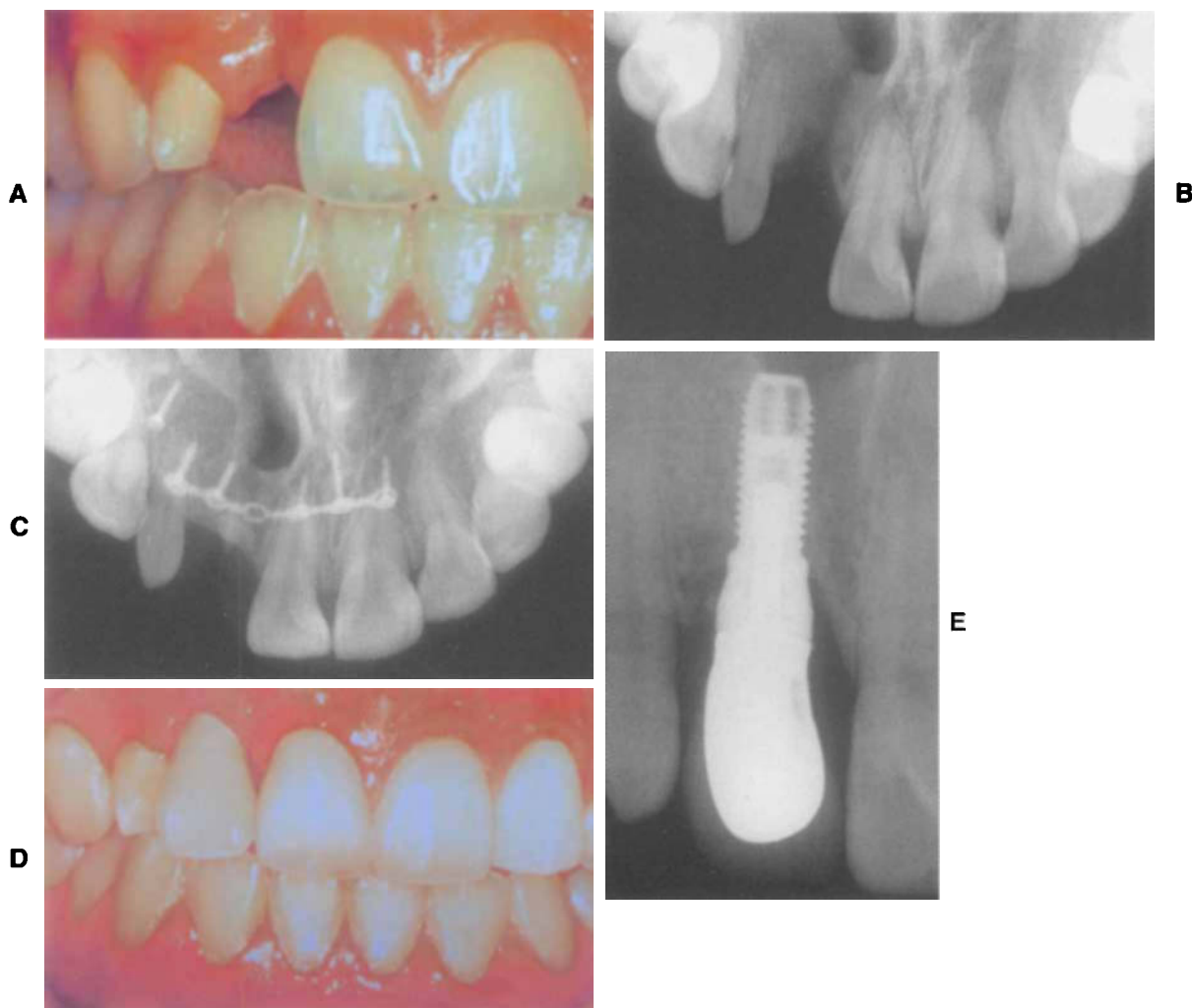
Prosthesis

Crown of acrylic baked to metal coping.

Figures

- Preoperative view of maxillary congenitally missing lateral incisor (Fig. 18-18, A).
- Preoperative occlusal radiograph. Note lack of bone density in area of missing lateral incisor (Fig. 18-18, B).
- Postoperative occlusal radiograph showing autogenous bone augmentation and its stabilization splint (Fig. 18-18, C).
- Postoperative view of final restoration in position (Fig. 18-18, D).
- Postoperative radiograph of restored implant (Fig. 18-18, E).

FIG. 18-18



■ CASE 19

Courtesy Alain Ruet, Vaugneray, France

Case as Presented

Male patient in his 60s. Edentulous maxilla. Edentulous mandible. Abundant available bone.

Probable Conventional Dentistry

Treatment Plan

Maxillary total removable denture. Mandibular total removable denture.

Implant Dentistry Treatment Plan

Implants

In maxilla, six self-tapping root form implants (Nobel Biocare/Steri-Oss). In mandible, four self-tapping root form implants (Nobel Biocare/Steri-Oss).

Prostheses

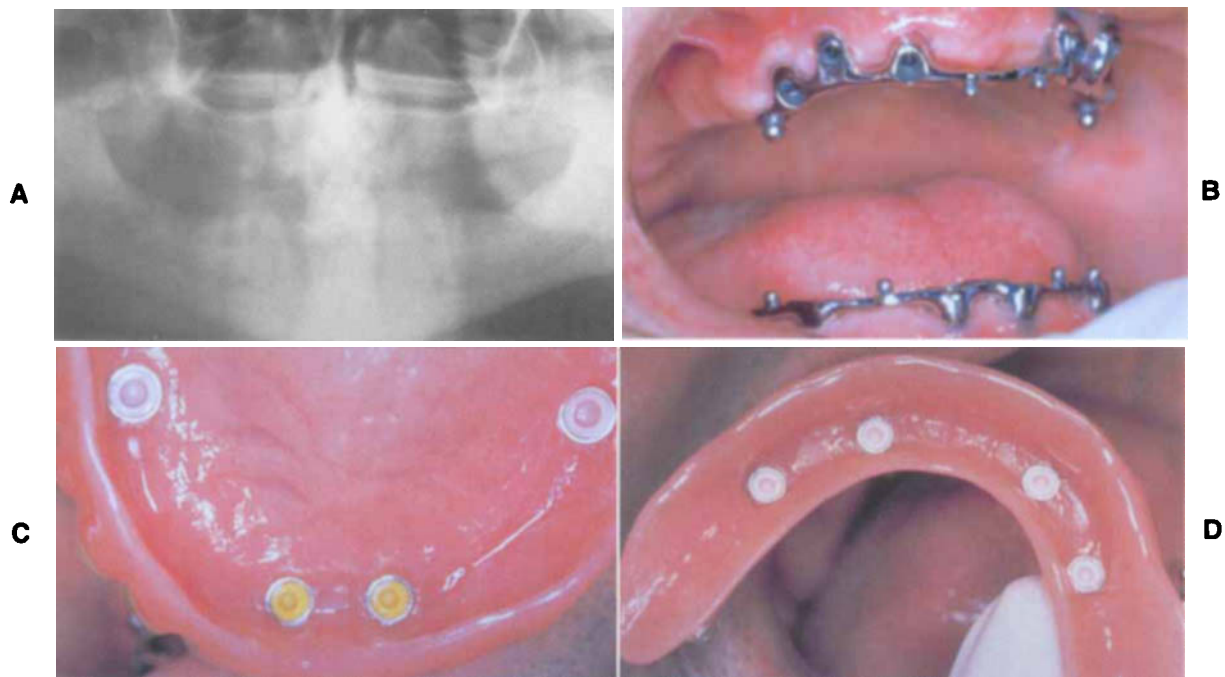
Maxillary splinting mechanism with provision for spherical attachments to offer retention for maxillary overdenture.

Mandibular splinting mechanism with provision for spherical attachments to offer retention for mandibular overdenture.

Figures

- Preoperative radiograph. Note abundance of available bone (Fig. 18-19, A).
- Postoperative view of maxilla and mandible with implant splinting mechanisms and their spherical attachments in position (Fig. 18-19, B).
- Postoperative view of tissue surface of maxillary overdenture showing spherical attachments in position (Fig. 18-19, C).
- Postoperative view of tissue surface of mandibular overdenture showing spherical attachments in position (Fig. 18-19, D).

FIG. 18-19



- Completed prostheses in position (Fig. 18-19, *E*).
- Postoperative radiographs showing 10 well-placed root forms implants (Fig. 18-19, *F*).

**E****F**

■ CASE 20

Courtesy Naoki Nishihama, Amagasaki, Japan

Case as Presented

Male patient in his 40s. Edentulous except for one maxillary and three mandibular molars with irreversible periodontal involvement.

Probable Conventional Dentistry

Treatment Plan

Maxillary total removable denture. Mandibular total removable denture.

Implant Dentistry Treatment Plan

Implants

Maxillary total subperiosteal implant. Five mandibular screw-type root form implants (ITI).

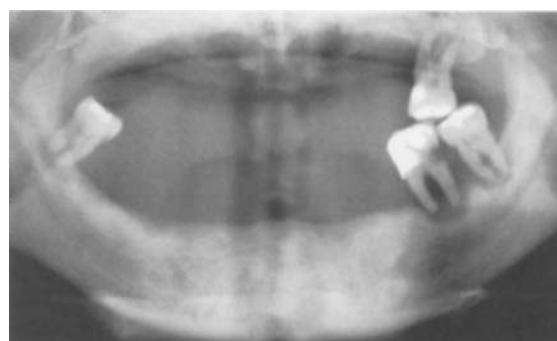
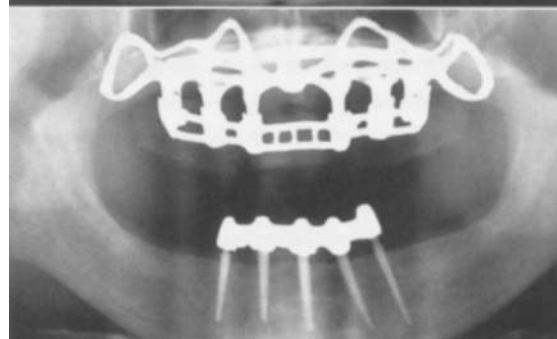
Prostheses

Maxillary complete-arch acrylic-to-metal fixed prosthesis. Mandibular splinted retention mechanism with semi-fixed overdenture.

Figures

- Preoperative radiograph (Fig. 18-20, *A*).
- Postoperative radiograph (Fig. 18-20, *B*).

FIG. 18-20

**A****B**

■ CASE 21

Courtesy Joel Rosenlicht, Manchester, Connecticut

Case as Presented

Male patient in his 50s. Totally edentulous maxilla, resorbed ridges. Mandible with six anterior teeth and serviceable bilateral partial removable denture.

Probable Conventional Dentistry**Treatment Plan**

Maxillary total removable denture.

Implant Dentistry Treatment Plan**Bone Enhancement**

Bilateral subantral augmentation.

Implants

Eight maxillary screw-type root form implants (Nobel Biocare/Steri-Oss).

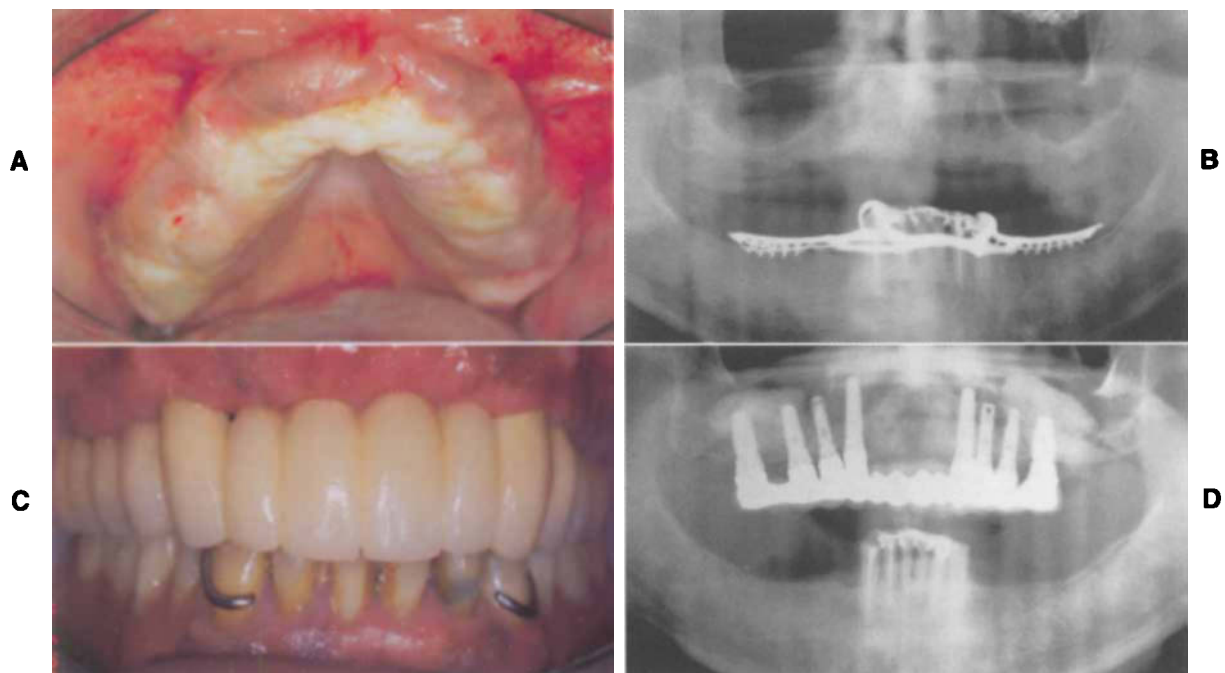
Prostheses

Maxillary complete-arch porcelain-to-metal fixed prosthesis.

Figures

- Preoperative view of edentulous maxilla (Fig. 18-21, A).
- Preoperative radiograph (Fig. 18-21, B).
- Postoperative view of maxillary complete-arch porcelain-to-metal fixed prosthesis in position (Fig. 18-21, C).
- Postoperative radiograph. Note extensive subantral augmentation (Fig. 18-21, D).

FIG. 18-21 |



■ CASE 22

Courtesy Terry Reynolds, Atlanta, Georgia

Case as Presented

Female patient in her 40s. Edentulous maxilla. Mandibular natural dentition.

Probable Conventional Dentistry Treatment Plan

Maxillary total removable denture.

Implant Dentistry Treatment Plan**Implant**

Maxillary total subperiosteal implant.

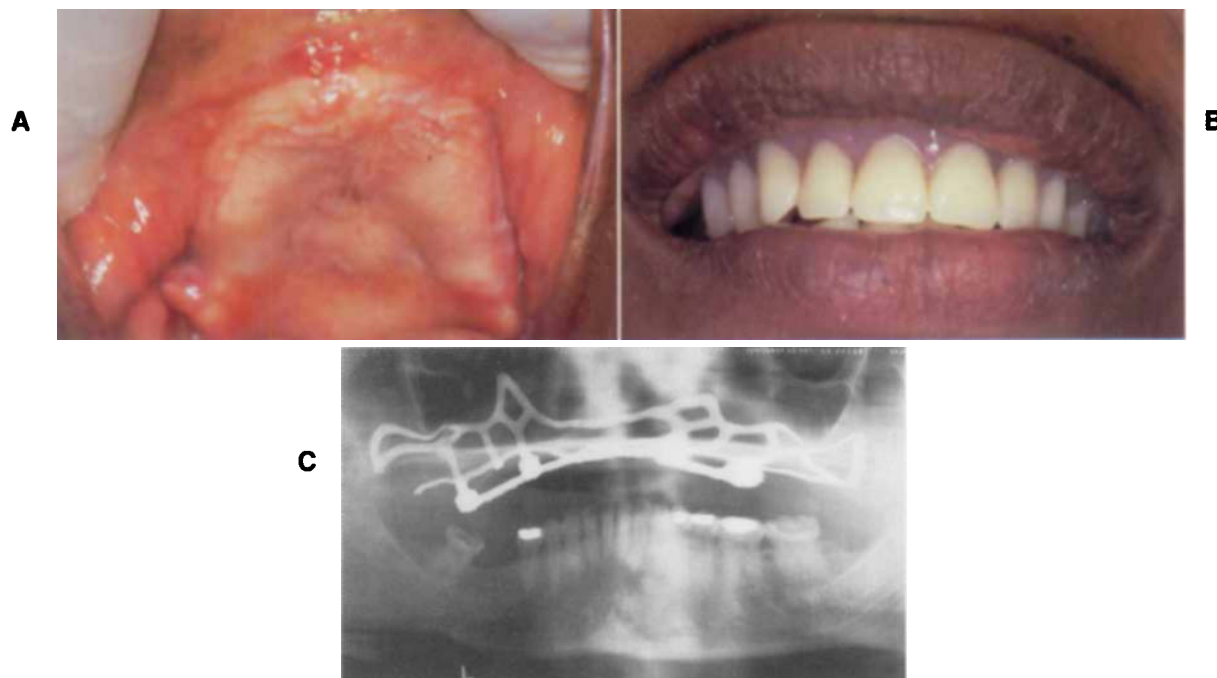
Prosthesis

Complete-arch fixed prosthesis, acrylic baked to substructure.

Figures

- Preoperative view of edentulous maxilla (Fig. 18-22, A).
- Postoperative view of maxillary prosthesis in position (Fig. 18-22, B).
- Postoperative radiograph. Maxillary total subperiosteal implant with four individual abutment heads (Fig. 18-22, C).

FIG. 18-22



■ CASE 23

Courtesy Richard Borgner, St. Petersburg, Florida

Case as Presented

Male patient in his 70s. All maxillary teeth show irreversible periodontal involvement and require removal. In mandible, except for right cuspid and central incisor and left cuspid and premolars, remaining teeth require removal.

Probable Conventional Dentistry Treatment Plan

Following removal of all teeth unable to be retained, maxillary total removable maxillary denture and mandibular partial removable denture.

Implant Dentistry Treatment Plan**Bone Enhancement**

Maxillary bilateral subantral augmentation.

Implants

In maxilla, eight root form implants (Suncoast Dental). In mandible, two screw-type root form implants (Suncoast Dental), two custom-made plate/blade form implants.

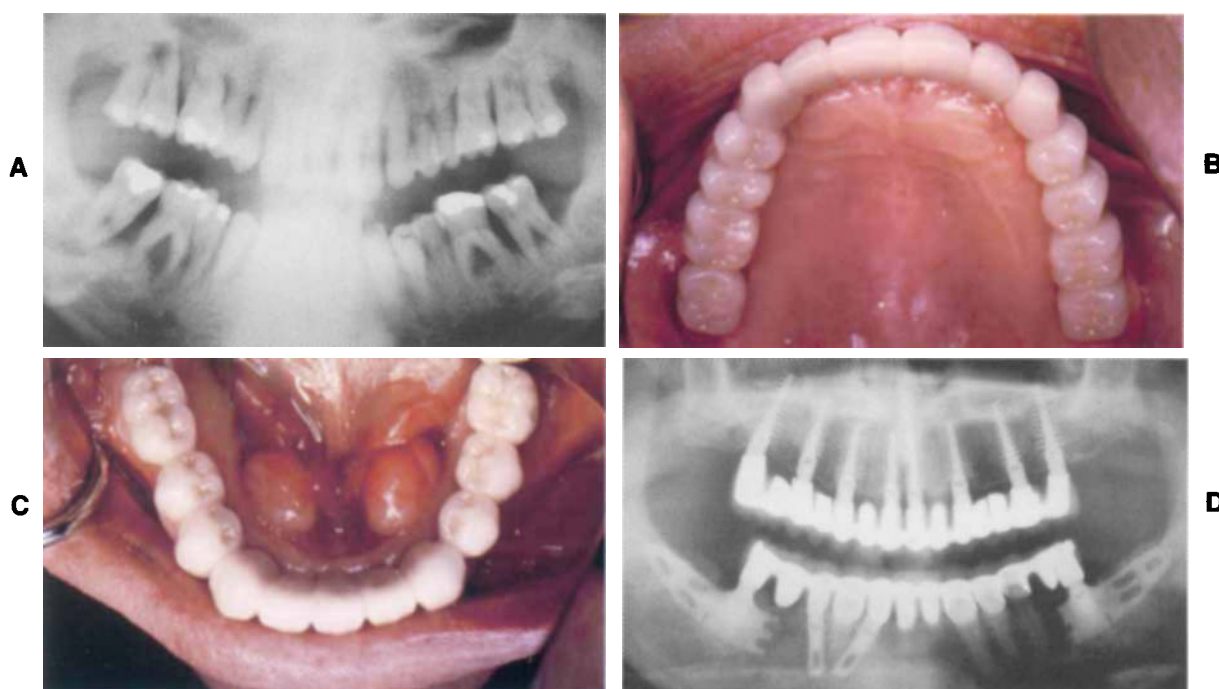
Prostheses

Maxillary and mandibular complete-arch porcelain-to-metal fixed prostheses.

Figures

- Preoperative radiograph (Fig. 18-23, A).
- Postoperative view of maxillary complete-arch fixed prosthesis in position (Fig. 18-23, B).
- Postoperative view of mandibular complete-arch fixed prosthesis in position (Fig. 18-23, C).
- Postoperative radiograph. Note bilateral subantral augmentation (Fig. 18-23, D).

FIG. 18-23



■ CASE 24

Courtesy Edward Mills, Atlanta, Georgia

Case as Presented

Female patient in her 50s. Edentulous maxilla showing moderate to advanced atrophy. Edentulous mandible showing severe atrophy. Loss of some vertical dimension. Obvious loss of facial contours. Unsatisfactory total removable dentures.

Probable Conventional Dentistry**Treatment Plan**

Maxillary and mandibular total removable dentures. Prognosis poor.

Implant Dentistry Treatment Plan**Bone Enhancement**

In maxilla, radiated cortical bone for bilateral subantral augmentation. In mandible, autogenous cranial bone graft to improve alveolar ridge. Repositioned and decompressed dehiscent alveolar nerve.

Implants

In maxilla, nine screw-type root form implants (Nobel Biocare/Steri-Oss). In mandible, total subperiosteal implant.

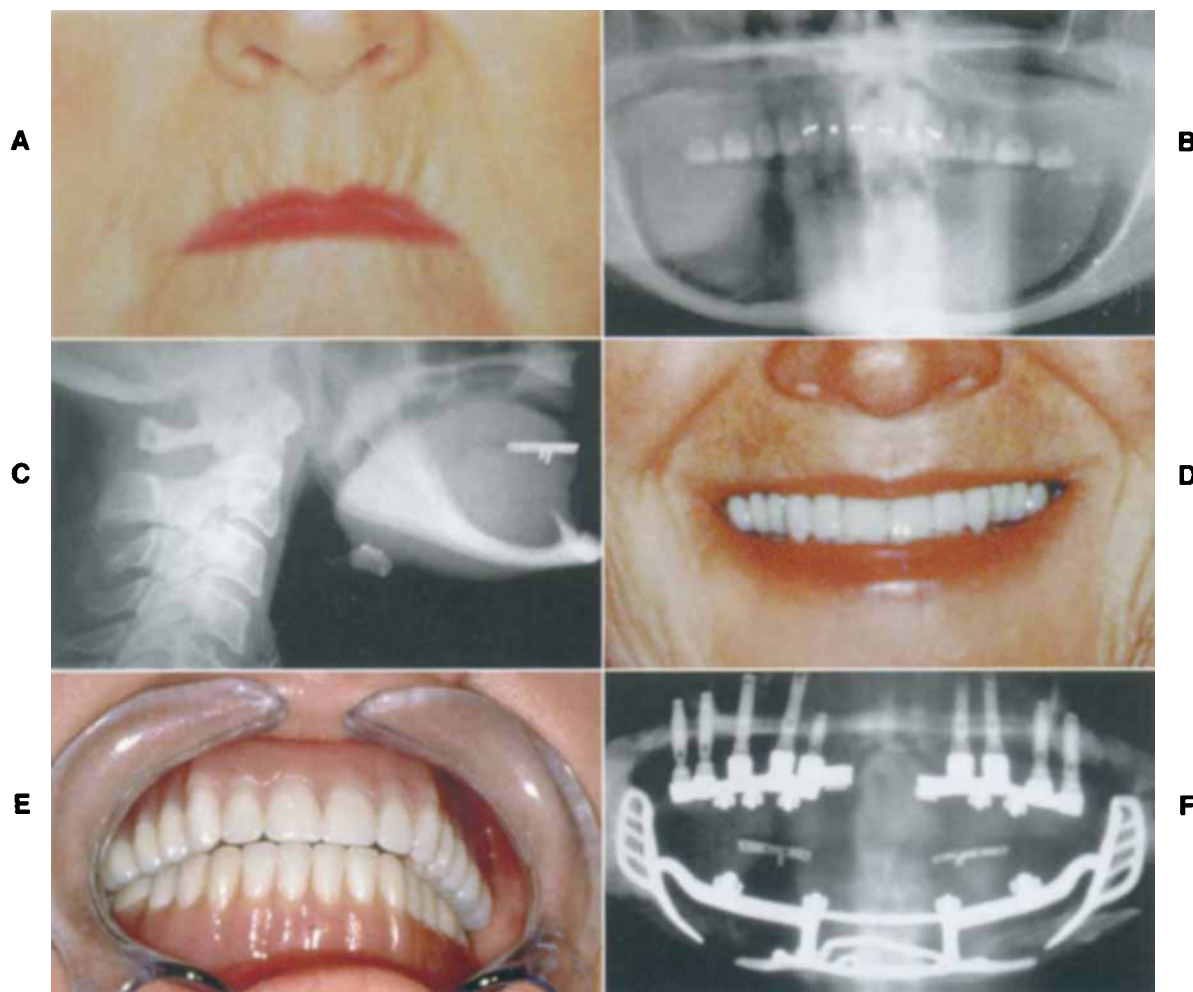
Prostheses

Maxillary porcelain-to-metal fixed prostheses. Mandibular semi-fixed overdenture.

Figures

- Preoperative view of patient. Note aged appearance (Fig. 18-24, A).
- Preoperative radiograph. Note severe mandibular atrophy (Fig. 18-24, B).
- Preoperative lateral skull radiograph. Note severe mandibular atrophy (Fig. 18-24, C).
- Postoperative view of esthetics (Fig. 18-24, D).
- Postoperative view of prostheses in position (Fig. 18-24, E).
- Postoperative radiograph of restored maxilla and mandible (Fig. 18-24, F).

FIG. 18-24



■ CASE 25

Case as Presented

Female patient in her 70s. Edentulous maxilla. Six anterior teeth in mandible, with abundant available bone in right and left posterior.

Probable Conventional Dentistry

Treatment Plan

Maxillary total removable denture. Mandibular partial removable denture.

Implant Dentistry Treatment Plan

Implants

Intramucosal inserts (Oratronics) fastened to tissue surface of maxillary total denture. In mandible, plate/blade form implants posteriorly (Oratronics), supplemented on left side by one-stage spiral implant (Oratronics).

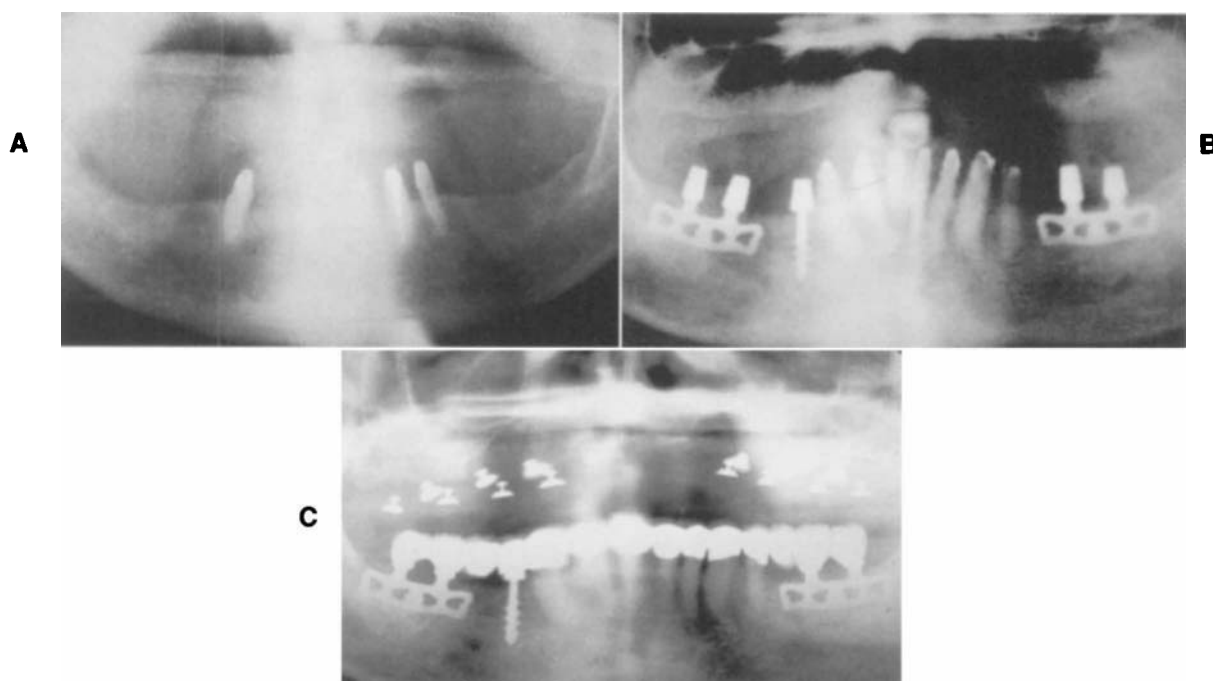
Prostheses

Maxillary total removable denture with intramucosal inserts. Mandibular complete-arch porcelain-to-metal fixed prosthesis supported by two plate/blade form implants, one spiral implant, and natural co-abutments.

Figures

- Preoperative radiograph (Fig. 18-25, A).
- Immediate postinsertion radiograph (Fig. 18-25, B).
- Postoperative radiograph after restoration (Fig. 18-25, C).

FIG. 18-25



■ CASE 26

Courtesy Takaharu Shimizu, Kobe, Japan

Case as Presented

Female patient in her 60s. Partially edentulous mandible.

Probable Conventional Dentistry**Treatment Plan**

Mandibular partial removable denture.

Implant Dentistry Treatment Plan**Implants**

Four endosseous root form implants (ITI) joined to four natural co-abutments for additional support.

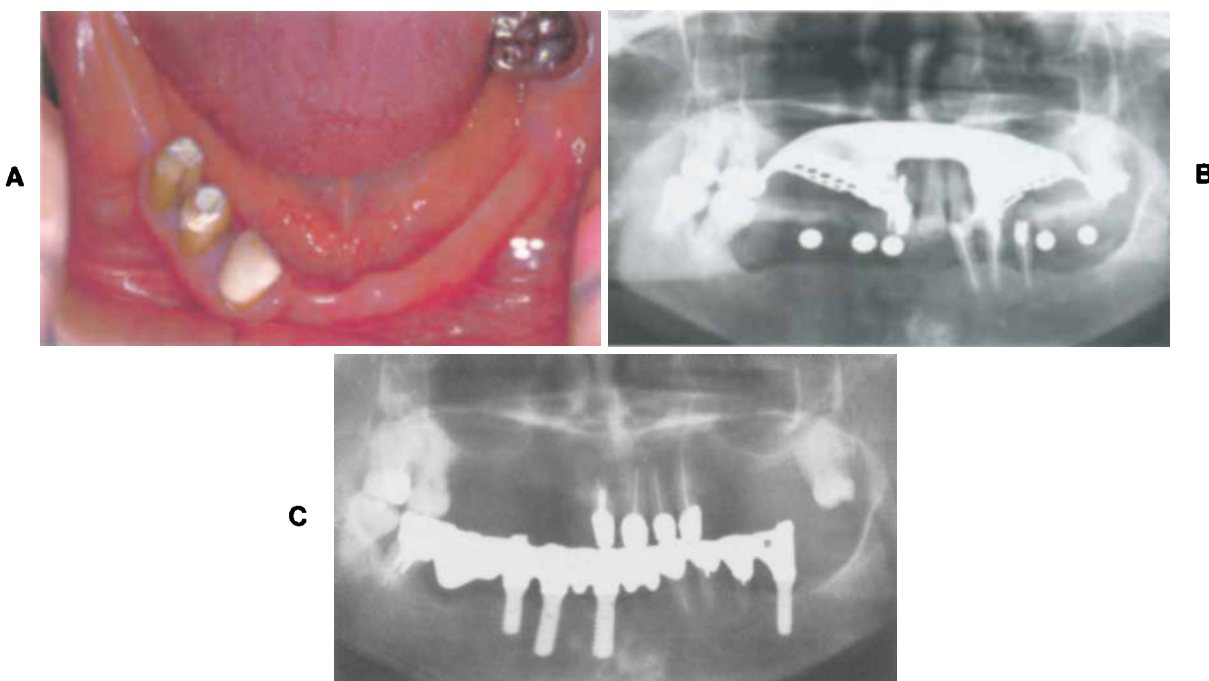
Prosthesis

Mandibular 13-unit porcelain-to-metal fixed prosthesis.

Figures

- Preoperative view of mandible (Fig. 18-26, A).
- Preoperative radiograph. Adequate mandibular available bone (Fig. 18-26, B).
- Postoperative radiograph. Interesting case of root forms acting as co-abutments with teeth (Fig. 18-26, C).

FIG. 18-26



■ CASE 27

Courtesy David Vassos, Edmonton, Alberta, Canada

Case as Presented

Male patient in his 60s. Mandible, previously treated, presents with six anterior teeth and four-unit porcelain-to-metal fixed prosthesis totally supported by screw-type root form implants on each side. Maxilla edentulous, with very little available bone under sinuses.

Probable Conventional Dentistry Treatment Plan

Maxillary total removable denture.

Implant Dentistry Treatment Plan

Bone Enhancement

Maxillary bilateral subantral augmentation using human irradiated bone and calcium sulfate, initially protected by resorbable barrier membrane.

Implants

Fourteen screw-type root form implants (Nobel Biocare/Steri-Oss).

Prosthesis

Fourteen individual porcelain-to-metal fixed crowns.

Figures

- Preoperative radiograph showing limited available bone in maxilla and previously restored mandible (Fig. 18-27, A).
- Postoperative subantral augmentation radiograph showing substantial increase in available bone for root form placement (Fig. 18-27, B).
- Postoperative view of crowns in position in maxilla (Fig. 18-27, C).
- Postoperative radiograph (Fig. 18-27, D).

FIG. 18-27



■ CASE 28

Courtesy Ralph Roberts, Rio Dell, California

Case as Presented

Female patient in her 60s. Edentulous maxilla. Mandibular posterior edentulism; six anterior teeth and left first premolar are satisfactory.

Probable Conventional Dentistry**Treatment Plan**

Maxillary total removable denture. Mandibular partial removable denture.

Implant Dentistry Treatment Plan**Implants**

Posterior ramus blade on each side, premolar area plate/blade form on each side (Pacific Dental).

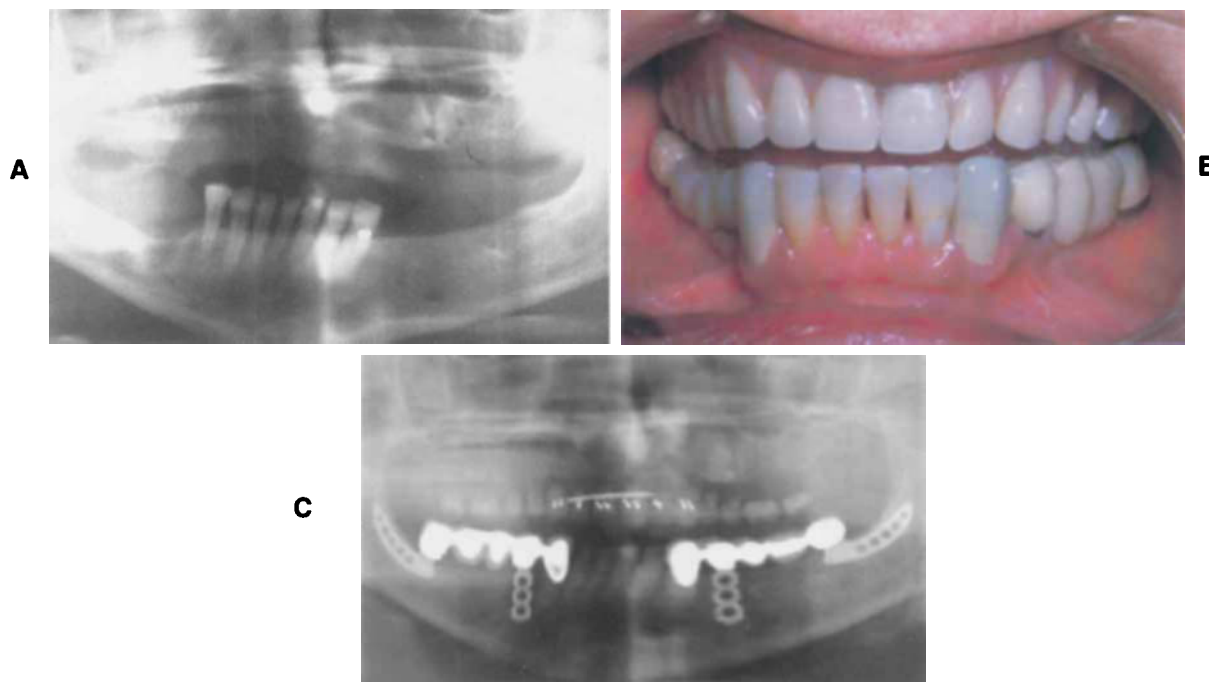
Prostheses

Mandibular bilateral porcelain-to-metal fixed prostheses each with one natural co-abutment and two implants as support.

Figures

- Preoperative radiograph (Fig. 18-28, A).
- Postoperative view of completed prostheses (Fig. 18-28, B).
- Postoperative radiograph showing two posterior five-unit fixed prostheses (Fig. 18-28, C).

FIG. 18-28



■ CASE 29

Courtesy Joe F. Warriner, Oklahoma City, Oklahoma

Case as Presented

Female patient in her 40s. Partially edentulous maxilla, shallow available bone under right sinus. Partially edentulous mandible, severely resorbed right posterior alveolar ridge, adequate available bone left alveolar ridge.

Probable Conventional Dentistry**Treatment Plan**

Maxillary partial removable denture. Mandibular partial removable denture.

Implant Dentistry Treatment Plan**Implants**

Maxillary left one-stage screw-type root form implant (Parc Dental Research), right posterior plate/blade form implant (Pacific Dental). Mandibular left posterior ramus blade implant (Pacific Dental), right posterior unilateral subperiosteal implant.

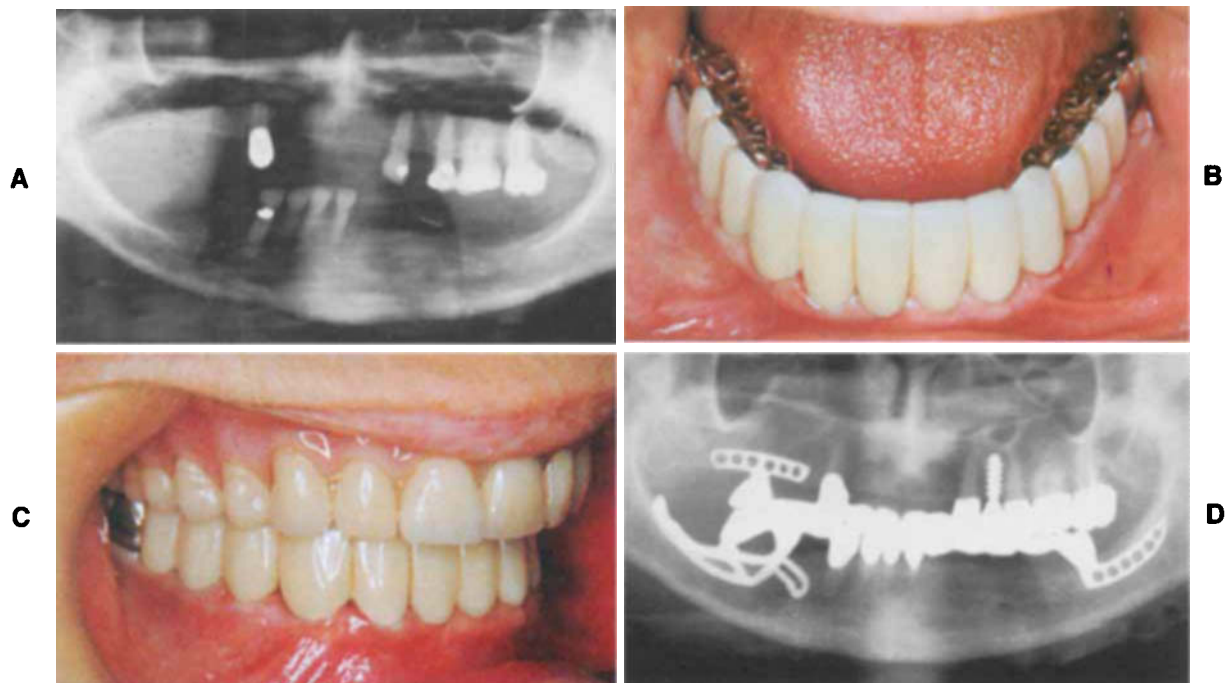
Prostheses

Maxillary complete-arch porcelain-to-metal fixed prosthesis. Mandibular complete-arch porcelain-to-metal fixed prosthesis.

Figures

- Preoperative radiograph. Note variations in residual alveolar ridge available bone in each arch (Fig. 18-29, A).
- Postoperative view of mandibular complete-arch fixed prosthesis (Fig. 18-29, B).
- Postoperative view of right sides of maxillary and mandibular complete-arch fixed prostheses (Fig. 18-29, C).
- Postoperative radiograph. Note that all implants are functioning in osteopreserved mode of tissue integration, including maxillary one-stage screw-type root form (Fig. 18-29, D).

FIG. 18-29



■ CASE 30

Courtesy Walter Knouse, Lumberville, Pennsylvania

Case as Presented

Two complete-arch porcelain-to-metal fixed prostheses in need of replacement. Several natural teeth and one plate/blade form implant diagnosed for removal.

Probable Conventional Dentistry

Treatment Plan

Removal of maxillary right third molar and three pontics anterior to it, and left lateral incisor. Insertion of maxillary partial removable denture. Removal of mandibular right premolar and left premolar and plate/blade form implant. Insertion of mandibular partial removable denture.

Implant Dentistry Treatment Plan

Bone Enhancement

Maxillary right subantral augmentation to accommodate plate form under sinus.

Implants

In maxilla, right posterior plate form implant (Omni) and root form implant (Steri-Oss) in left lateral incisor area. In mandible, custom-made plate form on each side. Endodontic stabilizers for right cuspid and first premolar.

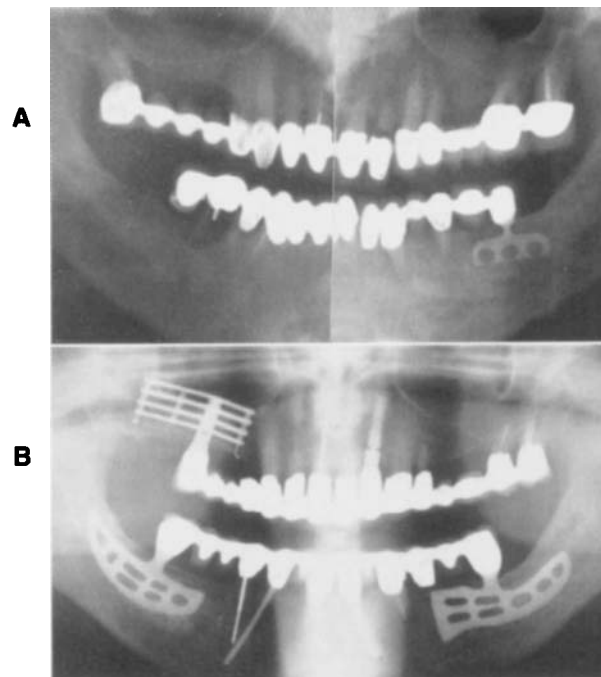
Prostheses

Maxillary and mandibular complete-arch porcelain-to-metal fixed prostheses.

Figures

- Preoperative radiograph (Fig. 18-30, A).
- Postoperative radiograph. Note four varieties of endosteal implants (Fig. 18-30, B).

FIG. 18-30



■ CASE 31

Courtesy Thomas Chess, South Pasadena, California

Case as Presented

Female patient in her 60s. Edentulous maxilla except for six anterior teeth. Edentulous mandible except for six anterior teeth and impacted left third molar.

Probable Conventional Dentistry**Treatment Plan**

Maxillary and mandibular bilateral partial removable dentures.

Implant Dentistry Treatment Plan**Implants**

Six root forms in maxilla and six root forms in mandible (Bicon), splinted to natural co-abutments.

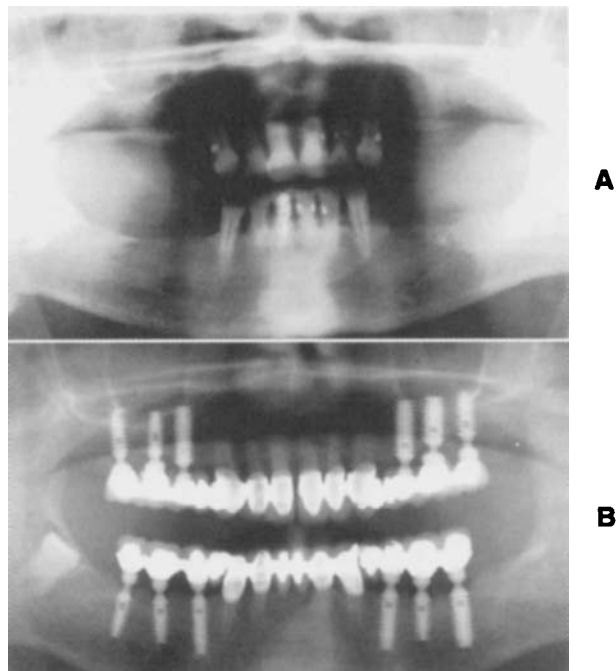
Prostheses

Two complete-arch porcelain-to-metal fixed prostheses.

Figures

- Preoperative radiograph. Note available bone (Fig. 18-31, A).
- Postoperative radiograph. Note relationship of maxillary root forms to sinuses (Fig. 18-31, B).

FIG. 18-31



■ CASE 32

Courtesy James L. Rutkowski, Clarion, Pennsylvania

Case as Presented

Female patient in her 70s. Edentulous maxilla. Posterior edentulism in mandible, with acceptable remaining teeth between right premolar and left lateral incisor.

Probable Conventional Dentistry**Treatment Plan**

Maxillary total removable denture. Mandibular partial removable denture.

Implant Dentistry Treatment Plan**Implants**

Mandibular circumferential subperiosteal implant.

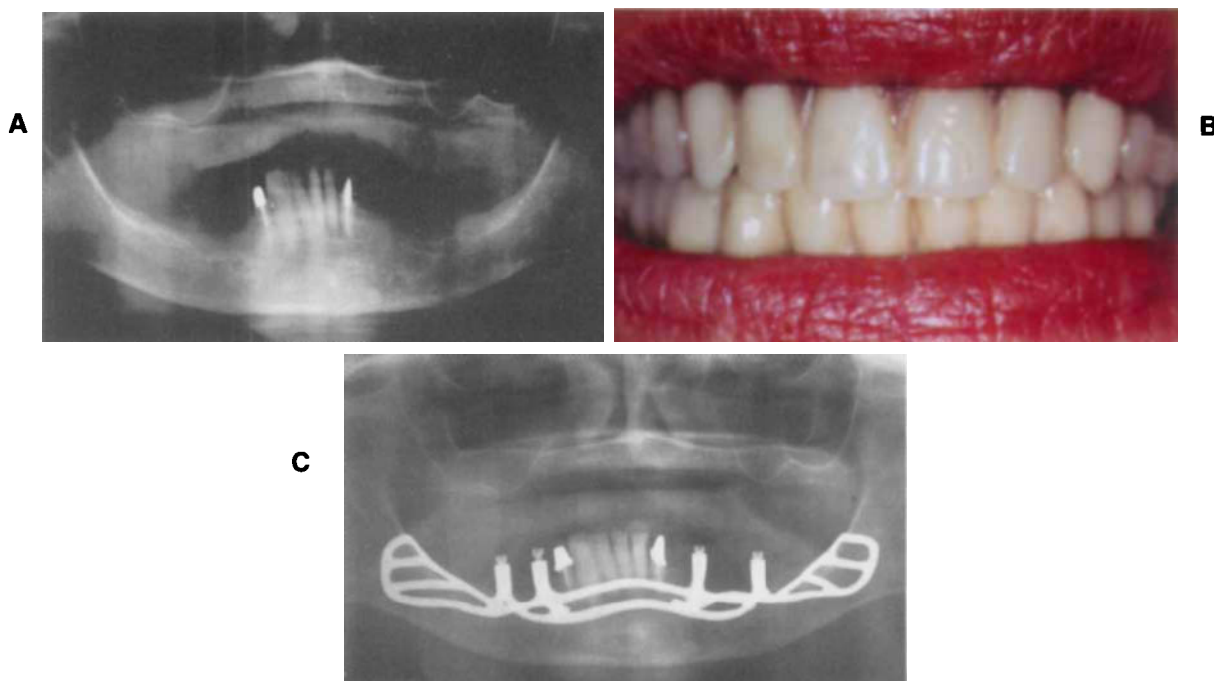
Prostheses

Maxillary total removable denture. Mandibular complete-arch fixed prosthesis.

Figures

- Preoperative radiograph (Fig. 18-32, A).
- Postoperative view of prosthesis in position (Fig. 18-32, B).
- Postoperative radiograph (Fig. 18-32, C).

FIG. 18-32



■ CASE 33

Courtesy Yasunori Hotta, Nagoya, Japan

Case as Presented

Female patient in her 50s. In maxilla, left and right second molars are in position, as well as right central incisor, left central and lateral incisors and cuspid. In mandible, left premolars and molars and right first molar are missing. Interocclusal clearance is minimal on both sides.

Probable Conventional Dentistry**Treatment Plan**

Maxillary and mandibular partial removable dentures. Perhaps limited fixed prostheses in addition.

Implant Dentistry Treatment Plan**Bone Enhancement**

Autogenous bone slurry harvested from bone filter, demineralized freeze-dried bone allograft and resorbable HA.

Implants

Screw-type and press-fit-type root forms (ITI, IMZ, Ankylos).

Prostheses

Maxillary complete-arch porcelain-to-metal fixed prosthesis. Mandibular three-unit fixed bridge supported by implant abutments.

Figures

- Preoperative view of maxilla (Fig. 18-33, A).
- Preoperative view of mandible (Fig. 18-33, B).
- Preoperative radiograph (Fig. 18-33, C).
- Postoperative view of completed prostheses. Note esthetics (Fig. 18-33, D).
- Postoperative view of maxilla (Fig. 18-33, E).
- Postoperative radiograph (Fig. 18-33, F).

FIG. 18-33



■ CASE 34

Courtesy Naoki Nishihama, Amagasaki, Japan

Case as Presented

Male patient in his 40s. Several acceptable maxillary teeth present. Central and lateral incisors, and left cuspid and first premolar are missing. Right mandible is edentulous distal to cuspid, with distal ridge resorption. Six acceptable anterior teeth are present. Left posterior mandible reveals failing four-unit fixed prosthesis supported by four screw-type root forms.

Probable Conventional Dentistry

Treatment Plan

Maxillary partial removable denture. Removal of left implant-supported fixed prosthesis. Mandibular partial removable denture.

Implant Dentistry Treatment Plan

Implants

Maxillary anterior subperiosteal implant. Mandibular right unilateral subperiosteal implant. Mandibular left unilateral subperiosteal implant.

Prostheses

Maxillary complete-arch acrylic-to-metal fixed prosthesis supported by implant and natural co-abutments. Mandibular complete-arch acrylic-to-metal fixed prosthesis supported by implant and natural co-abutments.

Figures

- Preoperative radiograph (Fig. 18-34, A).
- Postoperative view of maxillary restoration in position (Fig. 18-34, B).
- Postoperative view of maxillary and mandibular restorations in position. Note ridge lapping of maxillary incisors (Fig. 18-34, C).
- Postoperative radiograph (Fig. 18-34, D).

FIG. 18-34



■ CASE 35

Courtesy Eiichi Kojima, Tokyo, Japan

Case as Presented

Female patient in her 50s. Edentulous maxilla. Edentulous mandible except right central incisor, left incisors, and cuspid, which are acceptable. Ample available bone above inferior alveolar canal on each side, and in right first premolar cuspid and lateral incisor areas.

Probable Conventional Dentistry**Treatment Plan**

Maxillary total removable denture. Mandibular partial removable denture.

Implant Dentistry Treatment Plan**Implants**

In mandible, two plate/blade form implants posteriorly, and one plate/blade form in the right cuspid area (Oratronics).

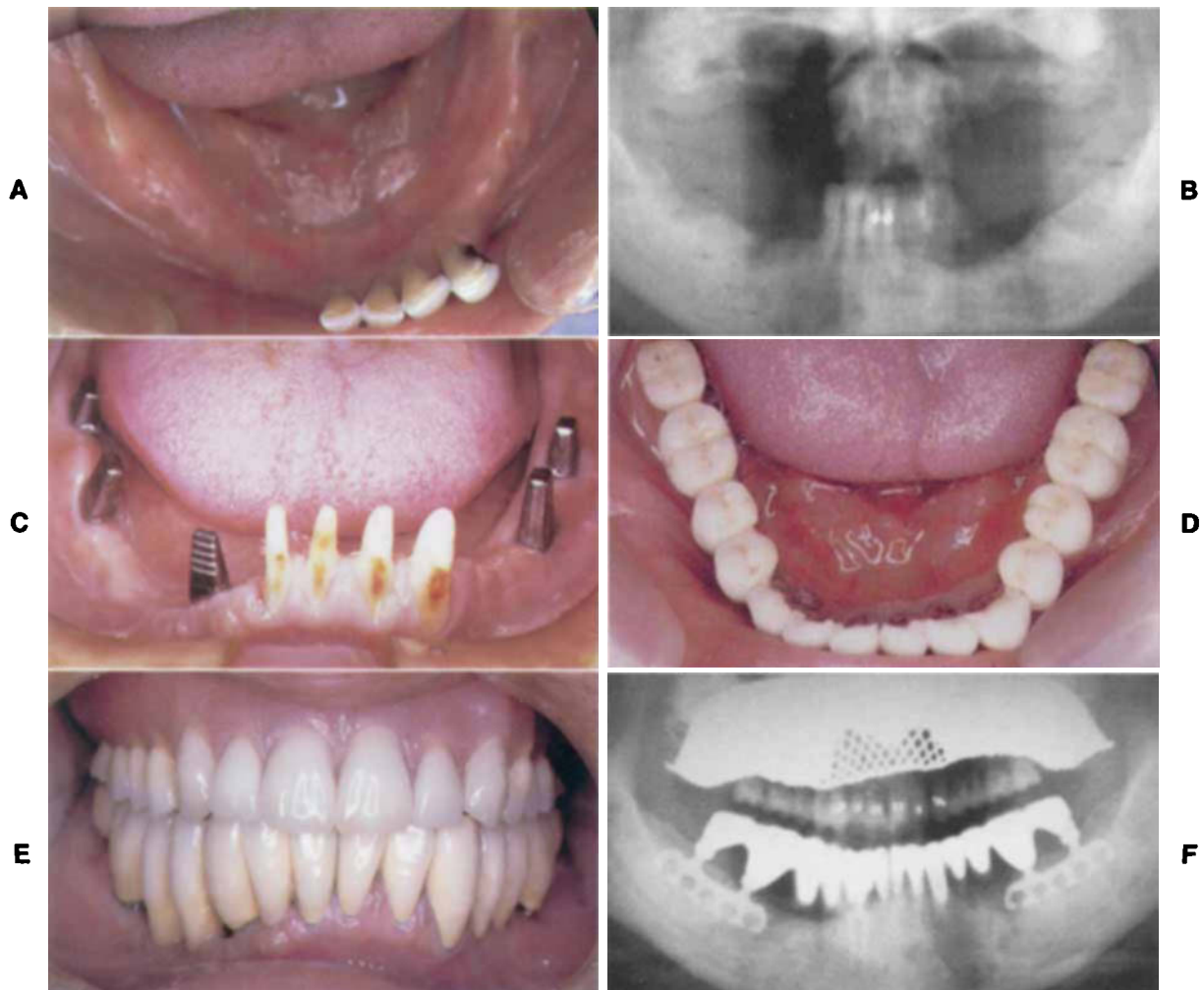
Prostheses

Maxillary total removable denture with metal palate. Mandibular 14-unit complete-arch porcelain-to-metal fixed prosthesis.

Figures

- Preoperative view of mandible showing four natural co-abutments (Fig. 18-35, A).
- Preoperative radiograph (Fig. 18-35, B).
- Postoperative view of prepared natural co-abutments and healed implants (Fig. 18-35, C).
- Postoperative view of occlusal aspect of complete-arch fixed prosthesis (Fig. 18-35, D).
- Postoperative view. Note mandibular posterior ridge lapping (Fig. 18-35, E).
- Postoperative radiograph (Fig. 18-35, F).

FIG. 18-35



■ CASE 36

Dr. Yasunori Hotta, Nagoya, Japan

Case as Presented

Male patient in his 50s. Edentulous maxilla except for left second molar and central incisor, and right central and lateral incisors and cuspid. Anterior maxillary teeth are irreversibly periodontally involved. Posterior interocclusal clearance is minimal on each side. In mandible, right molar area is edentulous. Available bone is adequate.

Probable Conventional Dentistry**Treatment Plan**

Following removal of all remaining maxillary teeth, total removable denture. Partial removable denture in mandible.

Implant Dentistry Treatment Plan**Bone Enhancement**

Autogenous bone graft slurry harvested from bone filter.

Implants

Twelve screw-type root form implants (ITI).

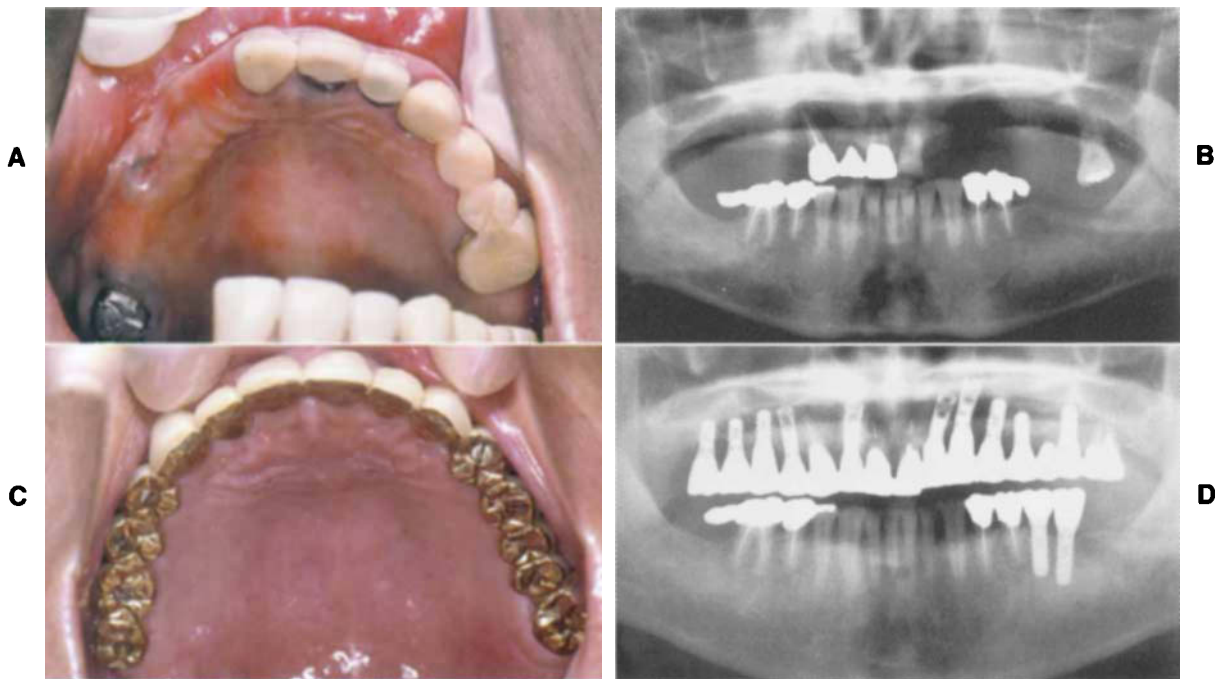
Prostheses

Maxillary complete-arch porcelain-to-metal fixed prosthesis. Mandibular left four-unit porcelain-to-metal fixed prosthesis.

Figures

- Preoperative view of maxilla (Fig. 18-36, A).
- Preoperative radiograph (Fig. 18-36, B).
- Postoperative view of maxilla (Fig. 18-36, C).
- Postoperative radiograph (Fig. 18-36, D).

FIG. 18-36



■ CASE 37

Courtesy Alain Ruet, Vaugneray, France

Case as Presented

Male patient in his 50s. Maxillary edentulism from right central incisor through entire left side. Mandibular arch well restored.

**Probable Conventional Dentistry
Treatment Plan**

Maxillary partial removable denture.

Implant Dentistry Treatment Plan**Implants**

Five root form implants in anterior and left maxilla (Nobel Biocare/Steri-Oss).

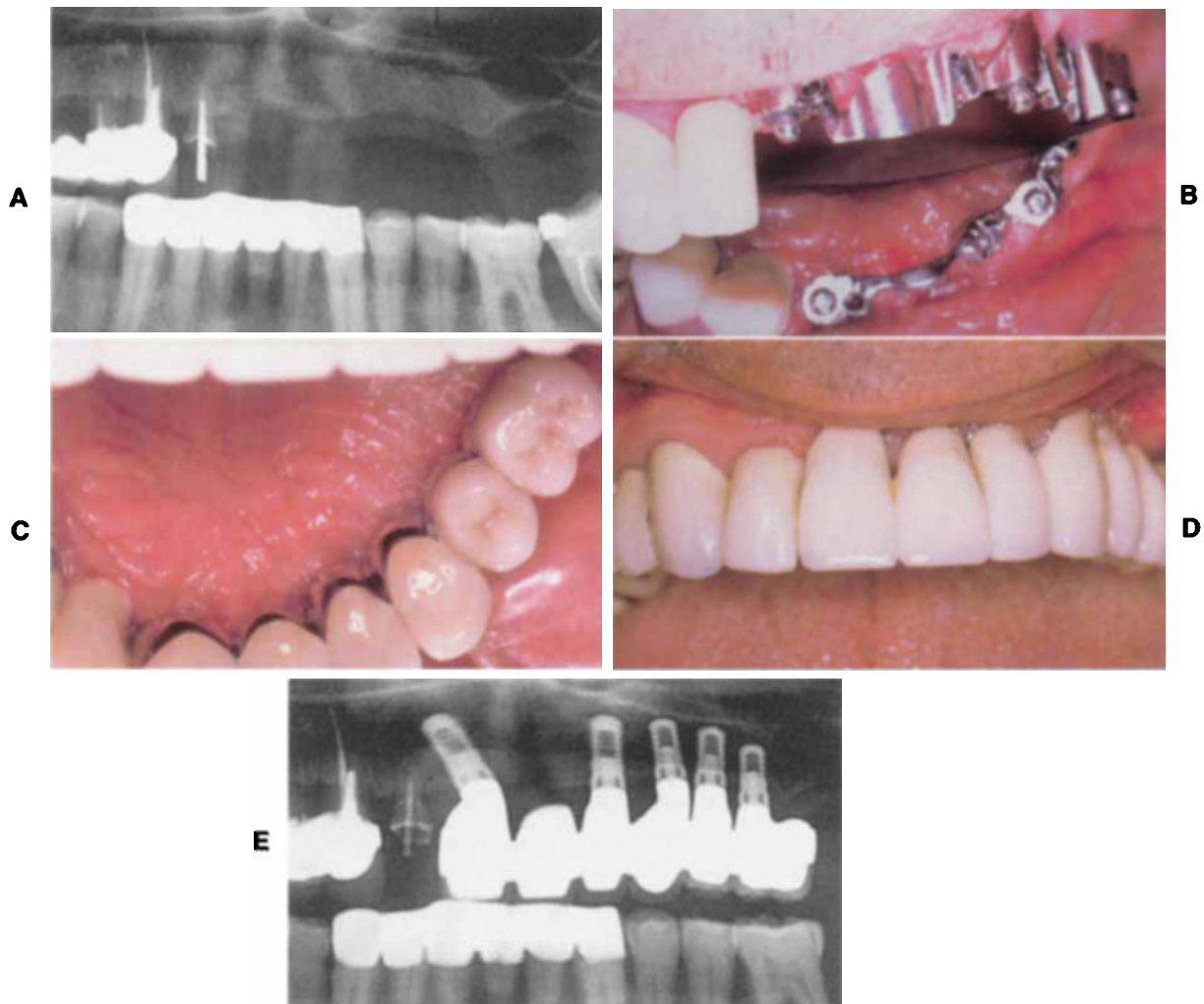
Prosthesis

Seven-unit porcelain-to-metal fixed prosthesis.

Figures

- Preoperative left quadrant radiograph (Fig. 18-37, A).
- Postimplant insertion view of splinting mechanism with embedded spherical attachments for retention (Fig. 18-37, B).
- Postoperative occlusal view of inserted prosthesis (Fig. 18-37, C).
- Esthetic result (Fig. 18-37, D).
- Postoperative left anterior radiograph (Fig. 18-37, E).

FIG. 18-37



■ CASE 38

Courtesy James L. Rutkowski, Clarion, Pennsylvania

Case as Presented

Female patient in her 50s. In maxilla, teeth present and acceptable from left second premolar to right cuspid. Some available bone under sinus on each side. Mandible presents with many teeth and no need of implants for restoration.

Probable Conventional Dentistry**Treatment Plan**

Maxillary partial removable denture. Mandibular fixed prostheses.

Implant Dentistry Treatment Plan**Bone Enhancement**

Maxillary bilateral subantral augmentation using freeze-dried demineralized bone.

Implants

Five screw-type root form implants (Paragon).

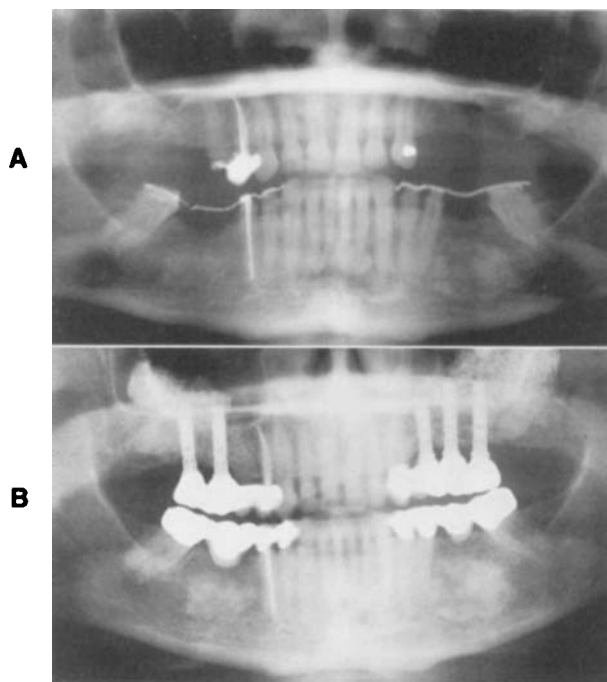
Prostheses

In maxilla, bilateral porcelain-to-metal fixed prostheses, each with one natural co-abutment. In mandible, conventional bilateral fixed prostheses.

Figures

- Preoperative radiograph (Fig. 18-38, A).
- Postoperative radiograph (Fig. 18-38, B).

FIG. 18-38



■ CASE 39

Courtesy Firdaus S. Jafri, Carol Stream, Illinois

Case as Presented

Male patient in his 50s. Severe generalized periodontitis. Many remaining teeth in mandible and maxilla.

Probable Conventional Dentistry

Treatment Plan

Removal of remaining maxillary teeth and insertion of total removable denture. Removal of several mandibular teeth, and insertion of partial removable denture.

Implant Dentistry Treatment Plan

Implants

Following removal and healing of all remaining maxillary teeth except cuspids, insertion of circumferential subperiosteal. Following removal of remaining mandibular teeth except right cuspid and first premolar, and left cuspid, premolars, and first molar, insertion of circumferential subperiosteal implant.

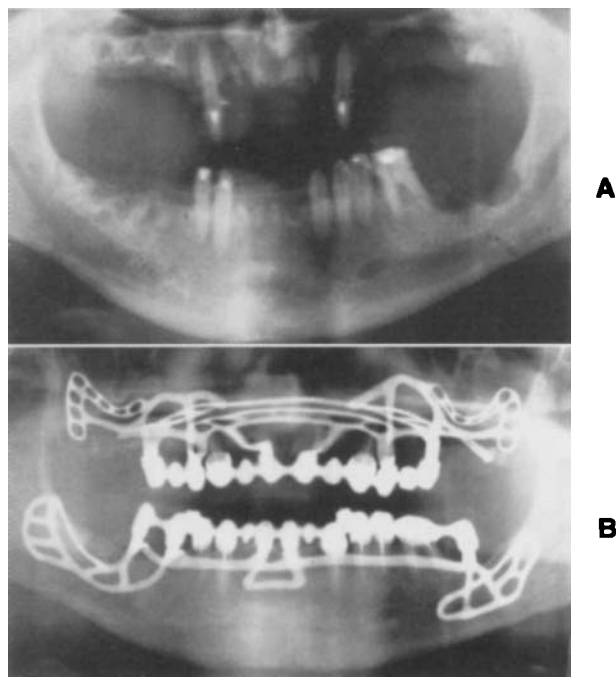
Prostheses

Using remaining teeth in each arch as natural co-abutments with implant abutments, two complete-arch porcelain-to-metal fixed prostheses were fabricated and inserted.

Figures

- Preoperative postextraction radiograph (Fig. 18-39, A).
- Postoperative radiograph with final prostheses in position (Fig. 18-39, B).

FIG. 18-39



■ CASE 40

Courtesy Takaharu Shimizu, Kobe, Japan

Case as Presented

Male patient in his 70s. Loss of maxillary right central incisor. Narrow alveolar ridge width.

Probable Conventional Dentistry**Treatment Plan**

Four-unit fixed prosthesis, with right lateral incisor and left central and lateral incisor abutments, and right central incisor pontic.

Implant Dentistry Treatment Plan**Implant**

Maxillary right central incisor area root form (ITI) after ridge expansion.

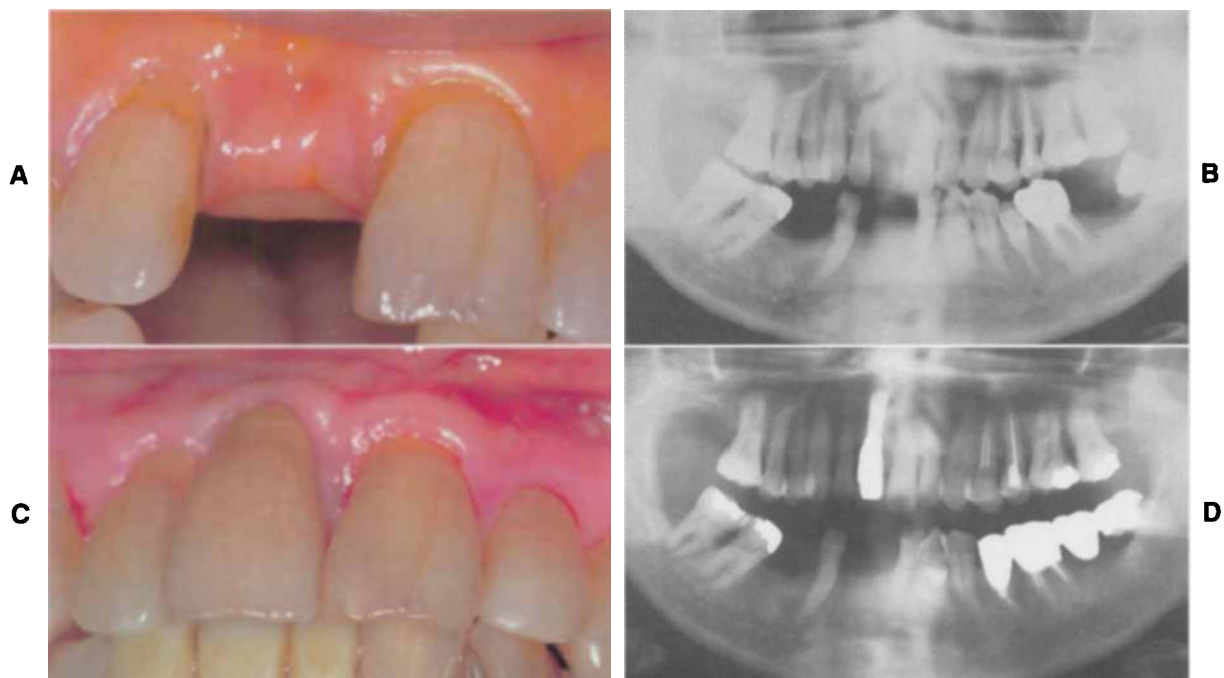
Prosthesis

Right maxillary central incisor porcelain-to-metal crown.

Figures

- Preoperative view of anterior maxilla (Fig. 18-40, A).
- Preoperative radiograph (Fig. 18-40, B).
- Postoperative view of completed restoration (Fig. 18-40, C).
- Postoperative radiograph (Fig. 18-40, D).

FIG. 18-40



■ CASE 41

Courtesy Terry Reynolds, Atlanta, Georgia

Case as Presented

Female patient in her 40s. In maxilla, six anterior teeth missing. In mandible, right first and second molars missing.

**Probable Conventional Dentistry
Treatment Plan**

Maxillary 12-unit porcelain-to-metal fixed prosthesis, from right first molar to left first molar, with six anterior pontics. Mandibular right five-unit porcelain-to-metal fixed prosthesis.

Implant Dentistry Treatment Plan**Implants**

Maxillary anterior interdental subperiosteal implant to provide abutments in edentulous area. Mandibular plate/blade form as pier abutment for fixed prosthesis.

Prosthesis

Ten-unit porcelain-to-metal fixed prosthesis.

Figures

- Preoperative view of edentulous area at anterior maxilla (Fig. 18-41, A).
- Postoperative view of porcelain-to-metal fixed prosthesis in position. Note ridge lapping (Fig. 18-41, B).
- Postoperative view of prosthesis with lips in repose (Fig. 18-41, C).
- Postoperative radiograph. Note anterior maxillary subperiosteal implant, and posterior pier abutment plate/blade form implant (Fig. 18-41, D).

FIG. 18-41



■ CASE 42

Courtesy Richard Borgner, St. Petersburg, Florida

Case as Presented

Male patient in his 50s. Left maxillary incisor missing. Adjacent teeth have not had prior dental restorations. Occlusion is atypical. Diastemas present.

Probable Conventional Dentistry**Treatment Plan**

Four-unit porcelain-to-metal fixed prosthesis, using right lateral and central incisors and left lateral incisors as abutments, with left central incisor restored as pontic.

Implant Dentistry Treatment Plan**Implant**

One root form implant (Suncoast Dental).

Prosthesis

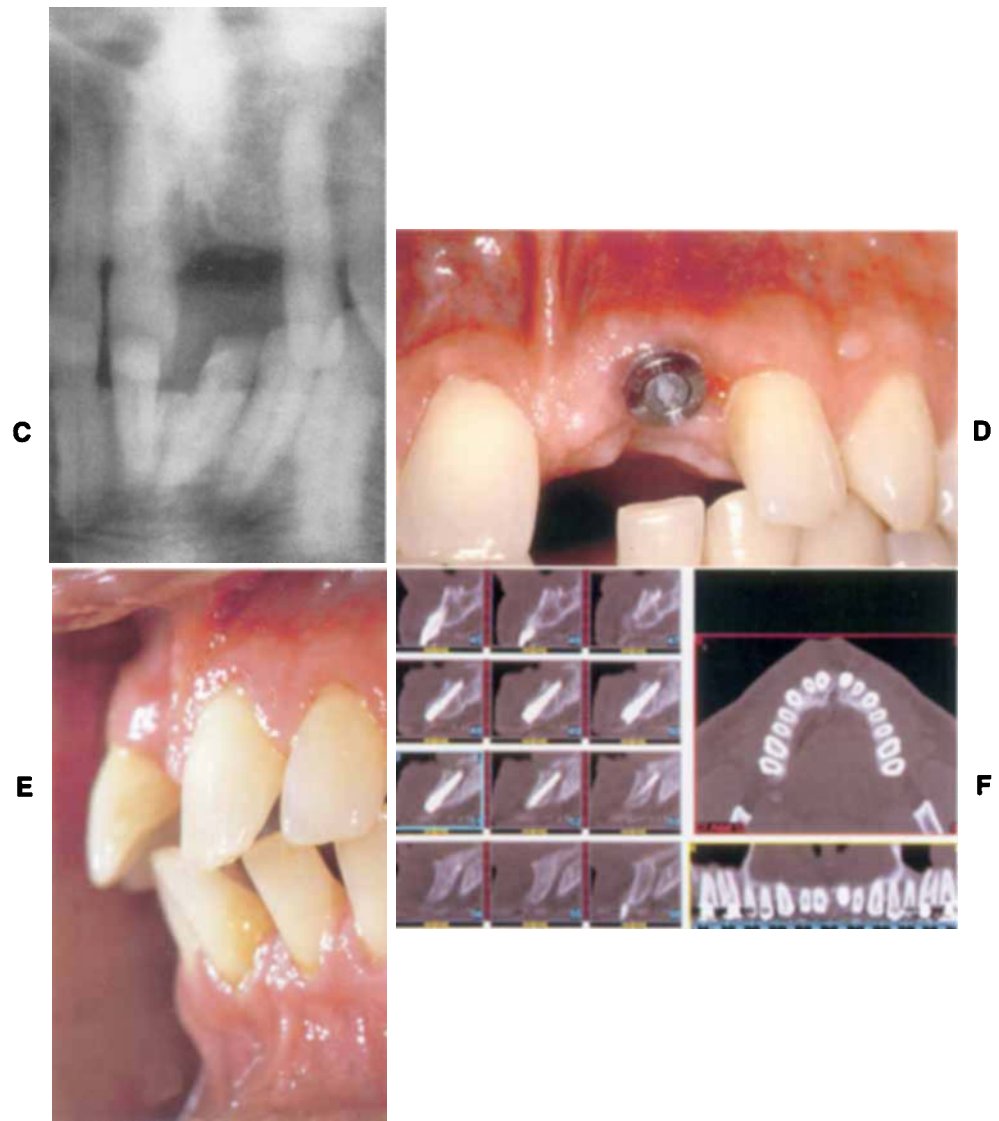
Individual porcelain-to-metal fixed crown.

Figures

- Preoperative frontal view of edentulous area of maxilla (Fig. 18-42, A).
- Preoperative incisal view of edentulous area of maxilla (Fig. 18-42, B).
- Preoperative radiograph (Fig. 18-42, C).
- Postoperative view showing healed implant in position (Fig. 18-42, D).
- Postoperative view of completed restoration in position (Fig. 18-42, E).
- Postoperative segmented radiograph showing implant positioning (Fig. 18-42, F).

FIG. 18-42





■ CASE 43

Courtesy Alfred Duke Heller, Worthington, Ohio

Case as Presented

Female patient in her 30s. Maxillary arch intact except for congenitally missing right and left lateral incisors. Intact and acceptable mandibular arch.

Probable Conventional Dentistry**Treatment Plan**

Maxillary six-unit anterior porcelain-to-metal fixed prosthesis using cuspids and central incisors as abutments, with lateral incisor pontics.

Implant Dentistry Treatment Plan**Implants**

Two root form implants (Miter and Bicon).

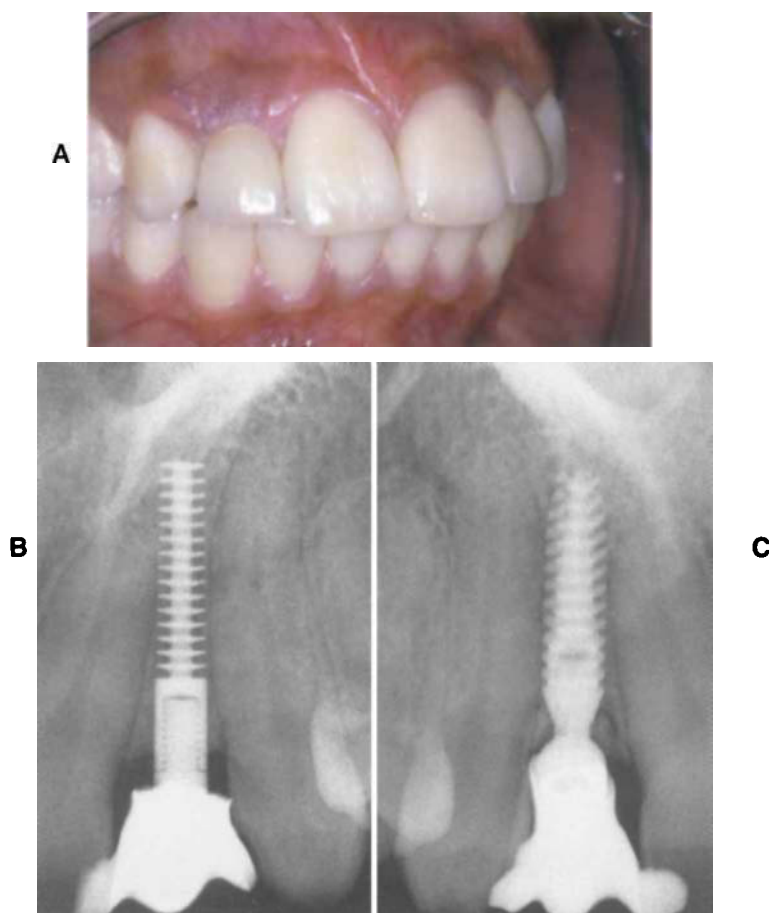
Prostheses

Two individual freestanding crowns each supported by root form implant. Lingual tabs or wings against lingual surfaces of cuspids and central incisors to promote stability of position.

Figures

- Postoperative view of crowns in position. Note esthetic result (Fig. 18-43, A).
- Postoperative radiograph of right lateral incisor area (Fig. 18-43, B).
- Postoperative radiograph of left lateral incisor area (Fig. 18-43, C).

FIG. 18-43



■ CASE 44

Courtesy Katsura Omura, Kyoto, Japan

Case as Presented

Male patient in his 40s. Edentulous maxilla except for left cuspid, second premolar, and second molar.

Probable Conventional Dentistry

Treatment Plan

Maxillary left five-unit partial fixed prosthesis. Maxillary partial removable denture. Mandibular unilateral partial removable denture.

Implant Dentistry Treatment Plan

Implants

Four osteointegrated two-stage plate/blade form implants (Oratronics) in anterior and right maxilla. One osteopreserved one-stage plate/blade form implant (Oratronics) in posterior left mandible.

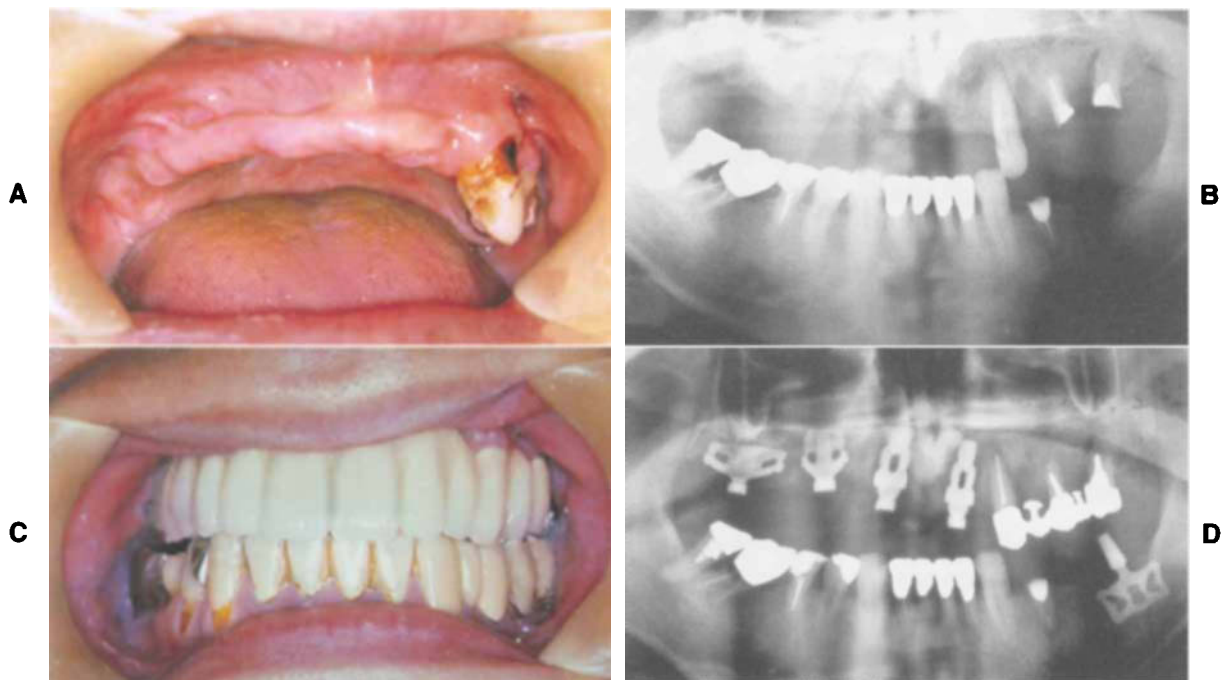
Prostheses

Maxillary nine-unit porcelain-to-metal fixed prosthesis extending from left lateral incisor to right second molar supported by implants. Mandibular four-unit porcelain-to-metal fixed prosthesis.

Figures

- Preoperative view of maxilla (Fig. 18-44, A).
- Preoperative radiograph (Fig. 18-44, B).
- Postoperative view of completed prostheses inserted (Fig. 18-44, C).
- Postoperative radiograph following implant insertions (Fig. 18-44, D).

FIG. 18-44



■ CASE 45

Courtesy Katsura Omura, Kyoto, Japan

Case as Presented

Female patient in her 20s. Left maxilla edentulous distal to cuspid. Except cuspids, all remaining mandibular teeth require removal.

Probable Conventional Dentistry**Treatment Plan**

Maxillary partial removable denture. Mandibular partial removable denture.

Implant Dentistry Treatment Plan**Implants**

In left maxilla, unilateral subperiosteal implant. In mandible, six one-stage plate/blade form implants (Oratronics).

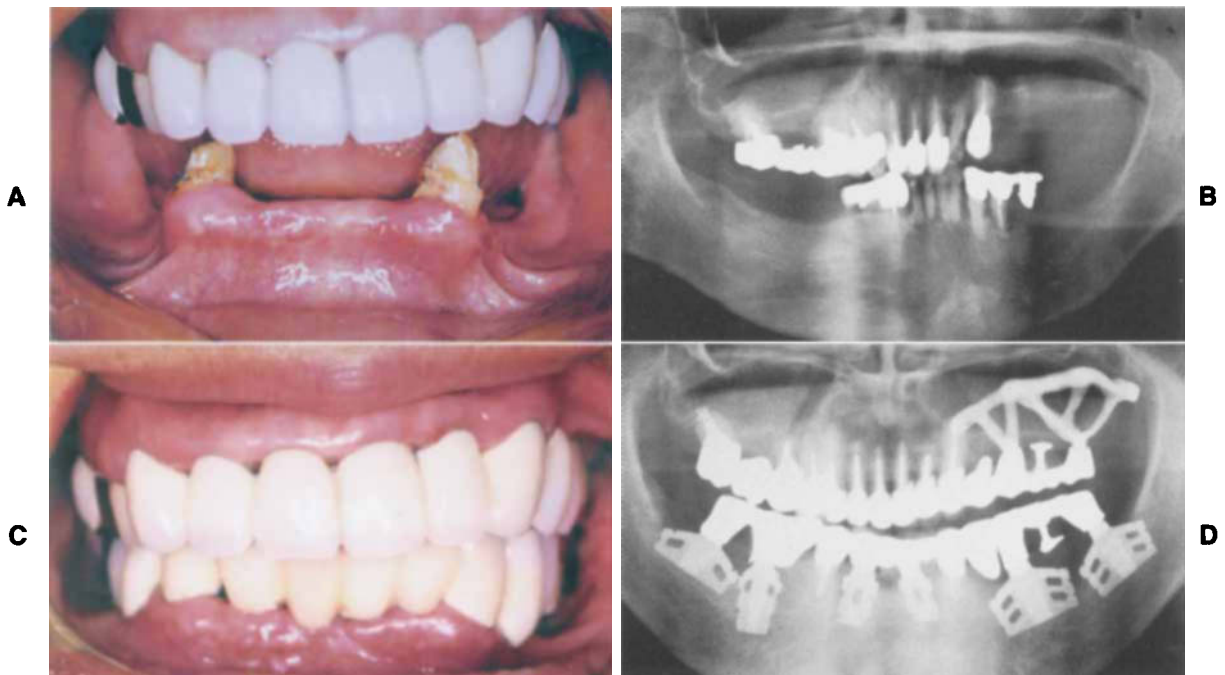
Prostheses

Maxillary 14-unit complete-arch porcelain-to-metal fixed prosthesis. In mandible, complete-arch porcelain-to-metal fixed prosthesis.

Figures

- Preoperative view following tooth removals (Fig. 18-45, A).
- Preoperative radiograph before tooth removal (Fig. 18-45, B).
- Postoperative view of completed prostheses (Fig. 18-45, C).
- Postoperative radiograph (Fig. 18-45, D).

FIG. 18-45



■ CASE 46

Courtesy Firdaus S. Jafri, Carol Stream, Illinois

Case as Presented

Male patient in his 50s. Remaining maxillary teeth are both premolars, right second premolar and cuspid, and left cuspid. All mandibular teeth present except left molars.

Probable Conventional Dentistry

Treatment Plan

Remove remaining maxillary teeth. Maxillary total removable denture.

Implant Dentistry Treatment Plan

Implants

Following removal of right second premolar and left first premolar, maxillary circumferential subperiosteal. After insertion, maxillary right and left cuspid and left second premolar were removed. Three endosseous root form implants inserted (Lifecore).

Bone Enhancement

Tricalcium phosphate (TCP) and demineralized freeze-dried bone.

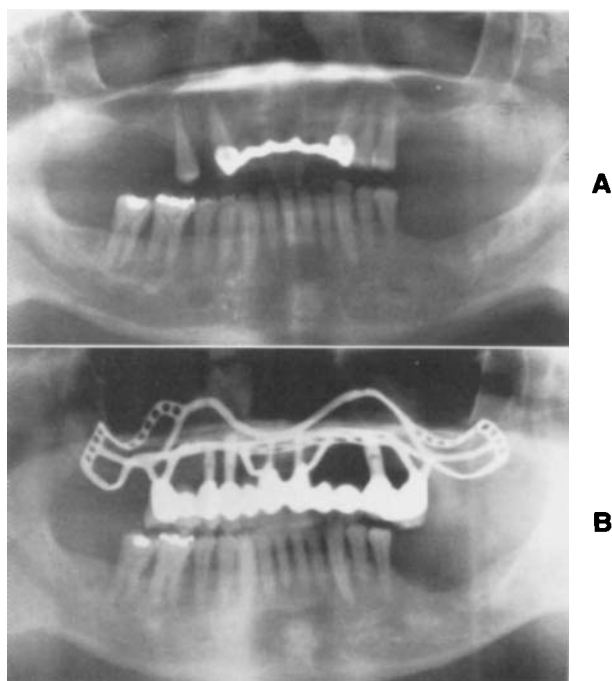
Prostheses

Complete-arch porcelain-to-metal fixed prosthesis.

Figures

- Preoperative radiograph. Note shallow available bone under sinuses (Fig. 18-46, A).
- Postoperative radiograph following removal of three remaining teeth and insertion of three root form implants (Fig. 18-46, B).

FIG. 18-46



■ CASE 47

Courtesy Emile Martin, Syracuse, New York

Case as Presented

Male patient in his 40s. Total edentulism in maxilla and mandible. Patient cannot function adequately with mandibular total removable denture.

Probable Conventional Dentistry**Treatment Plan**

Maxillary and mandibular total removable dentures.

Implant Dentistry Treatment Plan**Implants**

Mandibular total subperiosteal implant fabricated on CAT scan model.

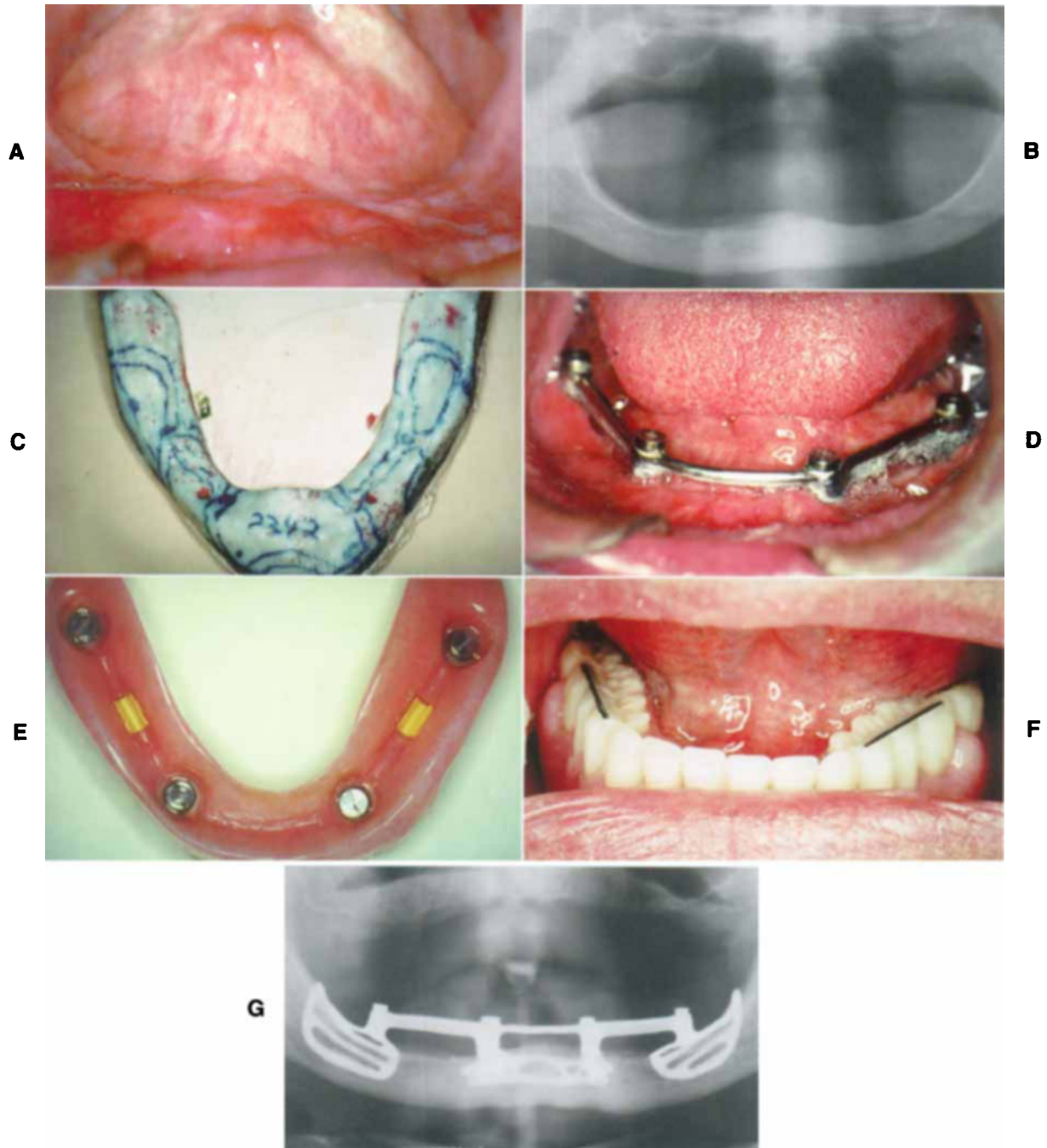
Prosthesis

Maxillary total removable denture. Mandibular complete semi-fixed overdenture retained by combination of magnets and clips.

Figures

- Preoperative view of mandible (Fig. 18-47, A).
- Preoperative radiograph (Fig. 18-47, B).
- CAT scan model (Fig. 18-47, C).
- Postoperative view of mandible. Note four magnetic retention devices (Fig. 18-47, D).
- View of undersurface of overdenture showing four magnetic retention devices and two plastic clips (Fig. 18-47, E).
- Postoperative view of prosthesis in position. Note cutter bars posteriorly (Fig. 18-47, F).
- Postoperative radiograph (Fig. 18-47, G).

FIG. 18-47



■ CASE 48

Courtesy Emile Martin, Syracuse, New York

Case as Presented

Male patient in his 40s. Maxilla edentulous on right side distal to cuspid. Maxilla left premolars and second and third molars missing. One millimeter of bone present inferior to right sinus. Left mandible missing second premolar and molars. Right mandible missing first premolar and second and third molars. Available bone is adequate in mandible.

Probable Conventional Dentistry**Treatment Plan**

Following required tooth removals, endodontic and operative treatment, removable maxillary and mandibular partial removable dentures.

Implant Dentistry Treatment Plan**Bone Enhancement**

Subantral augmentation of left maxilla, using demineralized freeze-dried bone allograft, barrier membrane (Gortex).

Implants

In maxilla, right unilateral subperiosteal, left four splinted screw-type root forms. In mandible, plate/blade form, left distal (Miter).

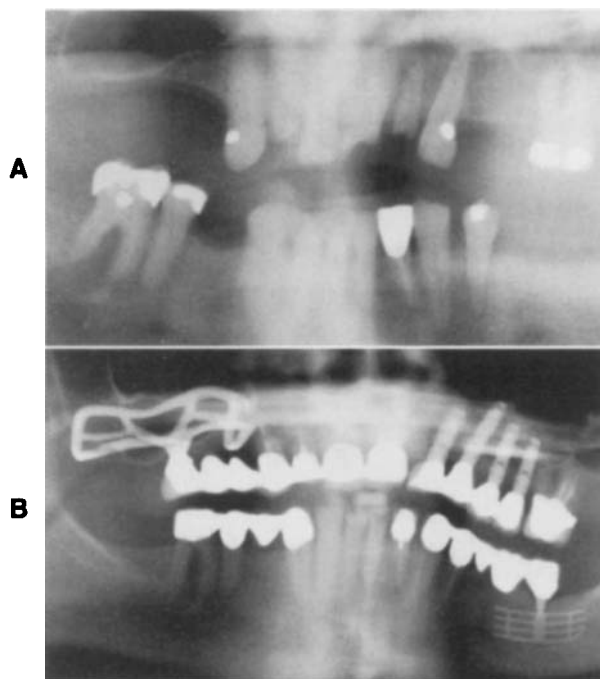
Prostheses

Maxillary porcelain-to-metal fixed prosthesis on right with natural co-abutments, and on left, four-unit implant-supported splint and individual crown. Mandibular left five-unit fixed prosthesis with natural co-abutments, and four-unit conventional fixed prosthesis on right.

Figures

- Preoperative radiograph (Fig. 18-48, A).
- Postoperative radiograph (Fig. 18-48, B).

FIG. 18-48



19 Endodontic Stabilizer Implants

Tooth Root Extension for Improved Prognosis

BENEFITS AND DESCRIPTION OF THE MODALITY AND SYSTEM USED IN THE TEACHING CASE

The purpose of endodontic stabilizers is to improve the prognosis of teeth with reversible complications, and their capability to act as abutment support. Endodontic stabilizers are not meant to save hopeless teeth. Adding length to the roots of teeth compromised by bone loss improves their crown-root ratio¹ (Fig. 19-1). A tooth successfully treated with endodontic stabilization may show improved gingival tissues and bone maintenance. The treated tooth is able to withstand increased functional loads within physiologic limits of health² and may be used as an abutment under a prosthesis.

Proven Long-Term Success/Survival Rates

Endodontic stabilizers have been used for more than 40 years. In that time, predictability and acceptable levels of success/survival have been demonstrated.³ Early problems related to retention of the stabilizer within the tooth root,⁴ a reliable endodontically oriented apical seal⁵ (Fig. 19-2), preventing cement expression beyond the apex at the time of insertion (Fig. 19-3), and long-term bone maintenance around the portion of the stabilizer that projects beyond the tooth apex (Fig. 19-4) have been overcome with improvements in design.⁶

The American Dental Association (ADA) Council on Education has stated that endodontic stabilization is a viable treatment option for correctly diagnosed and fully informed patients in the hands of a trained practitioner. The success/survival rates reported for endodontic stabilization are comparable with those of endosteal implants.³ There is no pergingival site, because the stabilizer does not penetrate gingiva. It passes through a tooth root into the bone beyond, sealing the apex as it does so (Fig. 19-5).

Technique-Permissive One-Visit Procedure

Because of the design of the implant and associated components, each step of the endodontic stabilization procedure

is technique-permissive. The treatment protocol is precise and logical. Endodontic stabilization is a standardized procedure that can be performed predictably as part of one's current endodontic regimen. Teeth that would otherwise not require endodontic treatment do require such treatment as an integral part of the endodontic stabilization protocol. Endodontic stabilization does not contraindicate any conventional endodontic regimen, so conjunctive use of one's favored endodontic protocols is recommended.

Restorative Options

Endodontic stabilization expands restorative options. All conventional restorative options applicable to endodontically treated teeth are applicable to teeth treated with endodontic stabilization. Depending on the condition of the crown of the tooth, options range from simple fillings to esthetic crowns. At times, the length of stabilizer that extends into the oral cavity after insertion may be trimmed above the level of the residual tooth structure to act as a basis for a **post-core** restoration before crown fabrication (Fig. 19-6). An additional option is to use a unified post-core/endodontic stabilizer combination (Fig. 19-7).

Unique Features

The Oratronics Osteo-Loc endodontic stabilizers used in the teaching case in this chapter offer several unique biomechanical advantages that are described in detail as part of the step-by-step insertion procedure, including an increased crown-root ratio, increased efficiency of the treated tooth root, firm retention of the stabilizer to the tooth root, a predictable apical endodontic seal, and the osteostimulatory effect of short collagenous fiber attachment to trabeculae of bone around the stabilizer interface (Fig. 19-8). Other unique design features promote expression of excess cement toward the oral cavity and away from the apex, and precise size-graduated instrumentation that protects the apex from cracking as the stabilizer passes through it and into its prepared osteotomy in available bone.

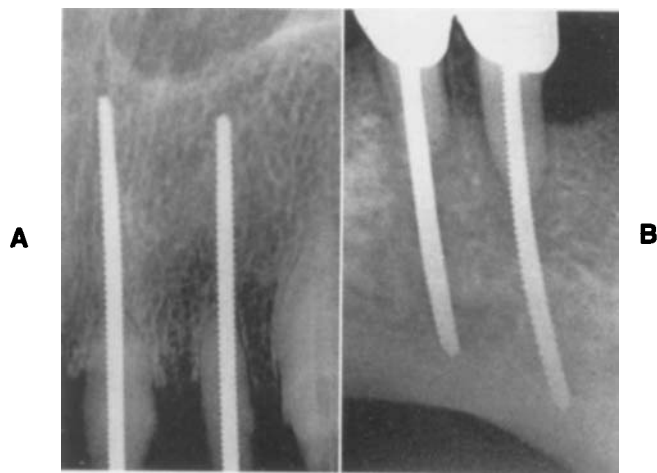


FIG. 19-1 ■ Periapical radiographs of endodontic stabilizers in maxilla (A) and mandible (B).

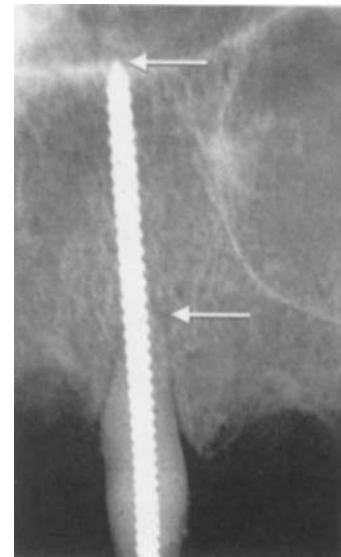


FIG. 19-2 ■ Apex, threading at area of apical seal, and opposite cortical plate (*arrows*).

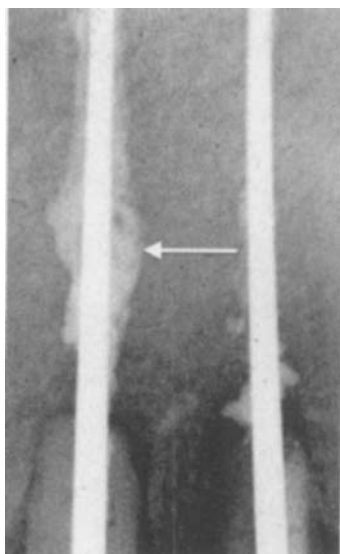


FIG. 19-3 ■ Smooth stabilizers lacking apical seal. Note expression of cement beyond apices (*arrow*).

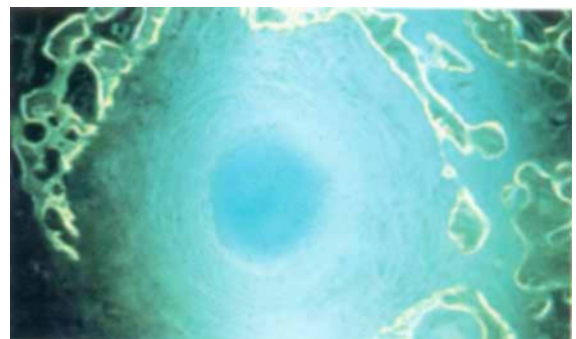


FIG. 19-4 ■ Excessive fibrous tissue around site of failed stabilizer.

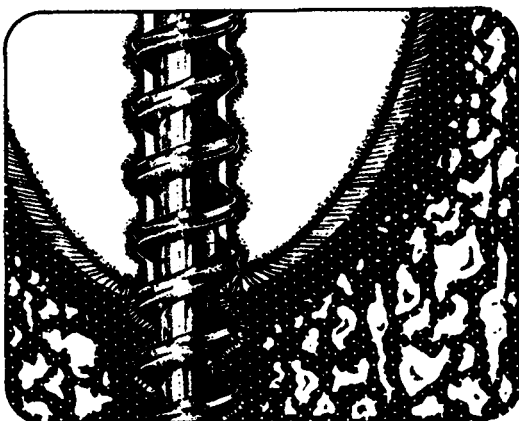


FIG. 19-5 ■ Stabilizer passing through apex into available bone.



FIG. 19-6 ■ Stabilizers (*arrows*) reinforcing coronal tooth structure.



FIG. 19-7 ■ One-piece endodontic stabilizer/endodontic filling/post-core combination.



FIG. 19-9 ■ Endodontic stabilizers and associated instrumentation.

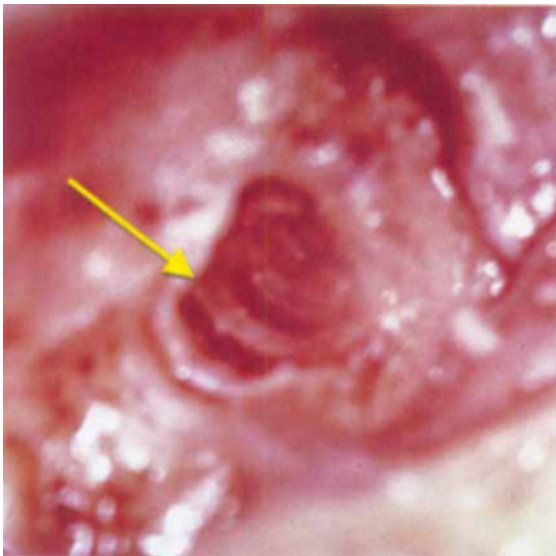


FIG. 19-8 ■ Site of successful stabilizer. Arrow indicates bone ingrowth into threading.

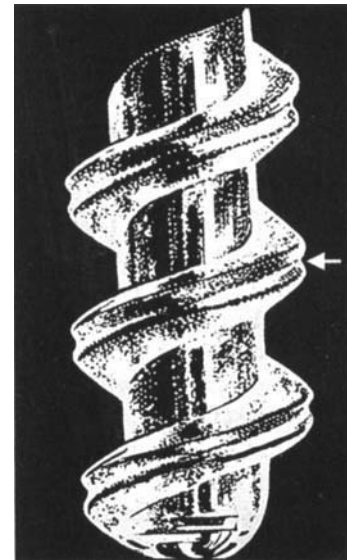


FIG. 19-10 ■ Stabilizer threads with sluceway indicated by arrow.

Configurations and Nomenclature of Endodontic Stabilizers

Osteo-Loc endodontic stabilizers are parallel-sided, threaded implants fabricated of titanium alloy (Fig. 19-9). Each has a hand-operated disposable handle for ease of manipulation. The one-piece post-core/endodontic stabilizer has a tapered abutment that can be further prepared for prosthodontic parallelism if necessary, with millimeter adjustment lines for guidance should adjustment for interocclusal clearance be

required. Each stabilizer has a continuous thread with a sluceway at its apex to guide cement expression coronally (Fig. 19-10). Stabilizer width from thread crest to thread crest is called the *major diameter*. The *minor diameter* is the width across the central column from thread-base to thread-base. The *land* is the distance on the central column from thread to thread. *Pitch* is the angle of each thread to the central column. Stabilizer No. 3 has a major diameter of 0.044 inches, and No. 4 has a major diameter of 0.069 inches.

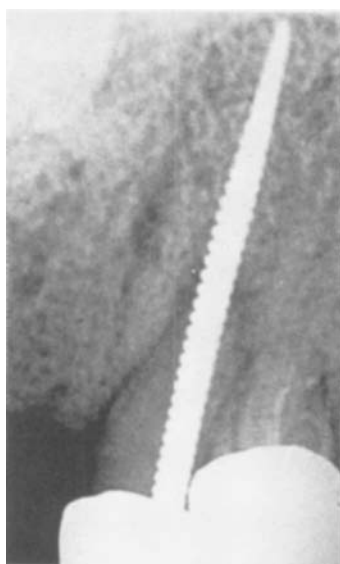


FIG. 19-11 ■ Postoperative radiograph of endodontic stabilization.

TYPICAL MAINSTREAM CASE—DIAGNOSIS, TREATMENT PLAN, AND END RESULTS

Case as Presented

Patient's Story. The tooth under consideration has previously been treated endodontically, or may require such treatment. A typical case involves a maxillary or mandibular anterior tooth, or first premolar. Active bone loss is minimal, and mobility of the tooth is often observed. The candidate tooth may show secondary or root decay, or a fracture at the gingival level that requires a crown-lengthening procedure, which in turn will further decrease the peri-cemental area of bone support. The crown-root ratio is unfavorable. The patient does not wish to have the tooth removed. Its prognosis, if untreated, is marginal. If the tooth is vital, the patient is willing to undergo root canal therapy to have it stabilized. Often, endodontic therapy is required to retain the tooth regardless of whether stabilization treatment is indicated.

Clinical Appearance. Examination reveals a compromised tooth, often slightly mobile, possibly broken down, and possibly discolored. The gingival condition is acceptable or can be improved with periodontal treatment. Crown lengthening may be required.

Radiographic Interpretation. The radiograph reveals a compromised tooth. Bone has been lost, but enough remains to retain the tooth.

Any periapical pathology that may exist can be successfully treated endodontically or with an apicoectomy.

Rejected Alternative Treatment Plans

The patient does not want the tooth removed. Removal of the tooth followed by the fabrication of a conventional fixed prosthesis, or single-tooth replacement using a root form implant, will not be required if the tooth is retained.

Endodontic stabilization using a smooth device, parallel-sided or tapered, is not advised. A relatively small amount of tension or compression can dislodge a smooth stabilizer from its seal against the internal aspect of the root canal. In addition, smooth stabilizers are incapable of sealing the apex endodontically, have the disadvantage of permitting the expression of endodontic sealants into bone beyond the apex, and do not promote an osteostimulatory effect to ensure long-term bone maintenance around the portion of the stabilizer that extends beyond the apex.

Accepted Treatment Plan

The case is diagnosed for treatment using a threaded endodontic stabilizer. This procedure requires one treatment visit that can usually be performed in approximately 1 hour of scheduled time.

Completed Case

Having the goal of endodontic stabilization firmly in mind during the treatment visit is important. The end result is presented now, to help the reader understand how each treatment step contributes to the final result, and to convey the satisfaction and benefits of treatment to the patient and practitioner.

Patient's Story. The treatment goals have been achieved. The treated tooth is now within the normal range of mobility. It can be esthetically restored, and has a better prognosis for use as an abutment under a prosthesis. Fine home care is easy to perform. The patient is fully informed about home care procedures.

Clinical Appearance. Unrestored, the tooth appears much as it did before treatment. Following restoration, it looks like any other esthetic tooth. The treated tooth has normal mobility. The gingiva is healthy. Pocket depths are within normal ranges.

Radiographic Interpretation. The postoperative radiograph reveals a well-positioned endodontic stabilizer implant that takes advantage of a substantial amount of available bone beyond the root apex. No cement is expressed through the apex during seating. The apex is in good condition. A review of postoperative radiographs of several cases reveals normal variations of this outcome (Figs. 19-11 and 19-12).

Microscopic Interpretation at the Interface. Following healing, light microscopy reveals that collagenous tissue of the peri-implant ligament around the stabilizer is organized in a manner similar to that of the periodontal ligament.^{7,8} Short fibers are bundled, anastomose, and are unified by a network of reticular fibers that bind them together.⁹ The collagen fibers attach to the first and usually second layers of trabeculae around the stabilizer implant, travel tangential to the stabilizer interface, and reinsert into other trabeculae, forming a sling around the stabilizer implant. The fibers are stressed sufficiently in function to stimulate the trabeculae, producing bioelec-

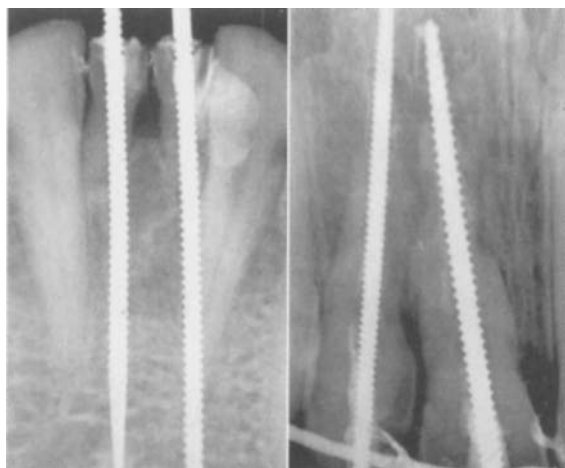


FIG. 19-12 ■ Periapical radiographs of successful endodontic stabilization.

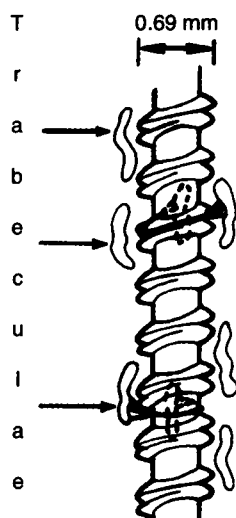


FIG. 19-13 ■ Peri-stabilizer ligament fibers stressed in function.

tric, cell-generated, and ground substance-generated responses, together contributing an osteostimulatory effect (Fig. 19-13). See Chapter 6 for a detailed explanation of osteostimulation.

EVALUATION OF CANDIDATE TEETH Surrounding Anatomic Structures

A minimum of 5 mm of available bone must be present beyond the apex of a tooth root to make endodontic stabilization worthwhile. The presence of 10 to 15 mm of available bone or more is not uncommon, and enhances the final result. Periapical radiography and digital manipulation during clinical examination are valuable diagnostic

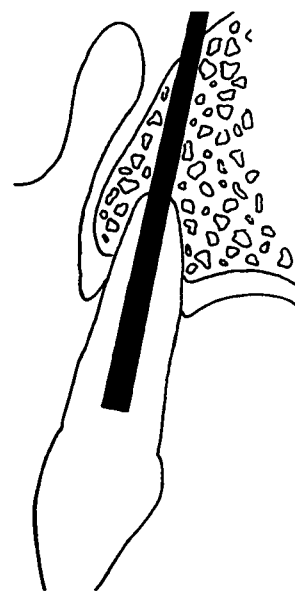


FIG. 19-14 ■ Stabilizer perforating undercut bone.

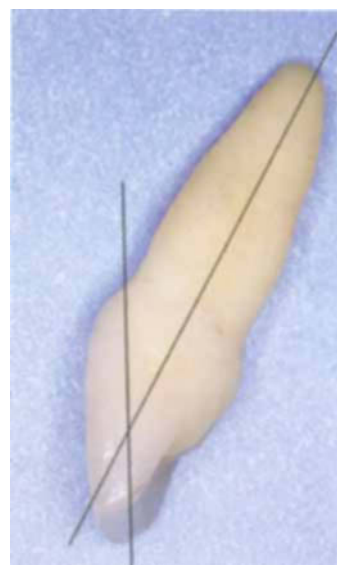


FIG. 19-15 ■ Natural tooth. Lines show divergent axial inclinations of crown and root.

aids. Landmarks such as the mental foramina, inferior alveolar canal, sinuses, and nasal cavity are to be avoided. Undercut areas should be noted to avoid possible perforation of cortical bone (Fig. 19-14). Such undercut areas do not preclude endodontic stabilization but may reduce the depth of available bone into which a stabilizer implant can be seated. In a tooth whose long axis diverges from that of its canal, particularly noted in the anterior maxilla, the labial enamel plate, if present, should not be penetrated (Fig. 19-15).

In consideration of the required available bone beyond the apex, endodontic stabilization in the mandible can be performed on first premolars, cuspids, and incisors in mainstream cases. Second premolars and molars are in

close proximity to the inferior alveolar canal, which should be avoided because of the risk of paresthesia. In the maxilla, teeth anterior to the sinus with sufficient available bone between the apex and the floor of the nasal cavity can be endodontically stabilized. These are most often the incisors, cuspids, and the lingual roots of the first premolars. In patients who have appropriate anatomy, second premolars can also be treated.

Periodontal Condition

The periodontal condition is considered at the time of diagnosis for endodontic stabilization. At the time of examination, if periodontal therapy is not needed, endodontic stabilization treatment may proceed. If periodontal therapy is required, it is best completed before determining whether to perform endodontic stabilization. Sometimes, endodontic and periodontal pathology must be treated simultaneously.

In borderline cases, in which saving the tooth may or may not be indicated, the science and art of dentistry converge. Patient habits, type of occlusion, opposing arch, oral hygiene, and general health have the same bearing as they do in diagnosing for conventional dental treatment. The art of dentistry is to make a correct judgment call, taking into account the patient's desires following discussion of benefits and risks, alternative treatment options, and probable treatment should complications occur.

Endodontic Condition

A precondition of diagnosis for endodontic stabilization is that the tooth can be successfully treated endodontically. Some teeth are treated with endodontic stabilization that otherwise would not have required endodontic therapy. Teeth that require endodontic treatment before stabilization are treated until readiness for final filling. The stabilizer is placed at the visit during which the tooth would have been filled. In cases that require apicoectomy, the stabilizer is inserted during the visit at which the apicoectomy is performed. With the apical area directly visible, the stabilizer osteotomy is prepared by passing the coordinated osteotomy drill through the apex, beyond the void created by the apicoectomy, and into the available bone apical to it. The stabilizer is then seated before closure. Such cases are not considered mainstream.

Tooth Root Anatomy

The anatomy of the apical third of the root and its orientation relative to available bone dictate the appropriate stabilizer configuration. In mainstream cases, the pathway of the canal from the crown to the apex is essentially parallel to the long axis of the root. The cross-sectional anatomy of some roots reveals substantial dentin surrounding the apical foramen, while in others the dentin surrounding the canal is sparse. The No. 3 Osteo-Loc stabilizer implant, 0.044 inches in major diameter, is gener-

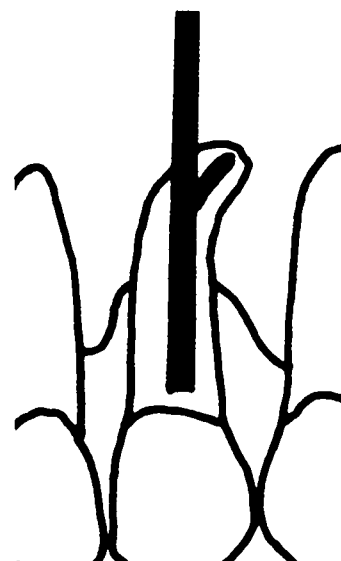


FIG. 19-16 ■ Path of endodontic stabilizer implant in tooth with curved root apex.

ally used for the mandibular incisors and maxillary lateral incisors, in which the amount of dentin surrounding the canal tends to be sparse. When the dentin surrounding the canal is sufficient, as is usually the case in other candidate teeth, the No. 4 stabilizer, measuring 0.069 inches in major diameter, is used.

Some tooth roots show curvature at the apical end, often observed in upper lateral incisors (Fig. 19-16). In such cases, the apical end of the canal is filled from the point of curvature to the apex, and the stabilizer osteotomy is created in a straight line, passing through the wall of the root to create a penetration that will be endodontically sealed as part of the procedure. Although this is not considered mainstream treatment, it is easy to visualize and treat successfully, and can be attempted after several mainstream cases have been treated. The prognosis is good in such cases.

The alveolar bone covering the buccal/labial of the root can be extremely thin. When widening canals of such teeth, it is advisable to exert pressure during reaming toward the lingual at all times, thus enlarging the canal at the expense of the lingual where there is adequate bone surrounding the apex. Preserving a thin buccal/labial plate of bone in this manner is considered part of mainstream endodontic stabilization.

The maxillary first premolar bears special consideration. It usually has two roots. Because its buccal root is near the buccal cortical plate, stabilization of the maxillary first premolar is best achieved by treatment of the lingual root only.

PLANNING AND PROCEDURES BEFORE ENDODONTIC STABILIZER IMPLANT INSERTION

The steps that are performed before the endodontic stabilizer insertion visit are shown in Box 19-1.

BOX 19-1 ■ PREOPERATIVE PROCEDURES

Complete all endodontic treatment until canal is ready for obturation
 Quantify available bone
 Determine whether to use standard stabilizer or post-core/stabilizer combination
 Prescribe preoperative medication

Complete All Endodontic Treatment Until Canal Is Ready for Final Obturation

Vital Cases. A variety of predictable endodontic treatment techniques can be performed before stabilization, using various instrumentation, medication, filling materials, and case sequencing. Some practitioners perform endodontic treatment as a one-visit procedure. In conventional protocols involving more visits, the stabilizer is inserted during the visit at which the canal would have been obturated. The most predictable results are obtained using one's conventional office routines for endodontic therapy.

Nonvital Cases. A nonvital tooth does not contraindicate endodontic stabilization. The endodontic protocol is typically longer and more complex in nonvital cases, but the same stabilization considerations apply as for vital cases. At the point in treatment at which one would fill the canal, the endodontic stabilizer is inserted. Treatment of nonvital cases is considered mainstream.

Previously Treated Cases. Stabilization cases that have previously been treated with endodontic therapy are subject to the same considerations. The materials obturating the canal are removed. The canal is retreated and cleansed until it is ready to be obturated again, at which time the stabilization protocol begins.

Cases That Require Apicoectomy. Endodontic stabilization in cases that require apicoectomy is not considered mainstream, but such treatment is successful when performed by an experienced practitioner.⁵ There are two options. In cases in which the apicoectomy and the endodontic therapy are performed by different practitioners, it is usually best to complete the endodontic therapy first, and then refer the patient for apicoectomy without a retrofill. Endodontic stabilization is then performed after healing at the apex, starting with removal of the endodontic filling, followed by canal enlargement and then the remainder of the stabilization protocol.

If the same practitioner performs the apicoectomy and the endodontic stabilization, the apicoectomy is best performed at the same visit, just before insertion of the endodontic stabilizer. The stabilizer osteotomy preparation and insertion can be performed before closure of the apicoectomy. Direct visualization ensures maximization of available bone and proper path of insertion.



FIG. 19-17 ■ Radiograph with millimeter grid to aid measurement.

Quantify Available Bone Using Diagnostic Radiography

The periapical radiograph is the best diagnostic tool for evaluating available bone for endodontic stabilization. A film packet with a millimeter grid affixed to it is used (Fig. 19-17). The resulting radiograph shows the apex and the opposite cortical plate, and allows the practitioner to estimate the number of millimeters of available bone between them fairly accurately. Palpation for areas of depression or sharp contour changes at the buccal/labial of the maxilla and the buccal/labial and lingual of the mandible in the vicinity of the root of the candidate tooth reveals whether all of the available bone observed on the radiograph can be used. In cases in which an undercut or unusual contour is detected, measurement of the usable depth of available bone needs to be exact to ensure that cortical bone is not penetrated. Final confirmation of available bone depth occurs during the procedure when a measurement radiograph is taken with a **millimeter measuring rod** positioned within the osteotomy that is being prepared. In this way, the practitioner can accurately count each millimeter, thereby avoiding error that can be introduced by distortion or elongation of the radiographic image.

Determine Whether to Use Unified Post-Core/Endodontic Stabilizer Combination

When a tooth has been targeted for endodontic stabilization, consider whether a unified post-core/stabilizer combination is required for the restorative phase. Such treatment is considered mainstream. Cases in which the coronal portion of the tooth is of inadequate size to support the planned restoration are suitable for treatment using a post-core/stabilizer combination, which provides an abutment. Both sizes of endodontic stabilizer are available as unified post-core/stabilizer combinations.

Sterilize Implant

Endodontic stabilizer implants are supplied sealed in two pouches. The outer pouch details the product information required by U.S. Food and Drug Administration (FDA) regulations and the U.S. Good Manufacturing Practices Act. Remove the inner pouch, which contains the stabilizer implant, but do not remove the implant from the pouch. Sterilize the implant in the conventional manner. Guidelines for gravity air displacement steam sterilization are for an exposure time of 30 minutes at 250° F (121° C) or 15 minutes at 270° F (132° C). For prevacuum steam sterilization, an exposure time of 4 minutes is required at 270° F (132° C). Once sterilized, the pouch is transferred to the surgical tray setup. If desired, stabilizer implants can be resterilized following cleansing.

Prescribe Preoperative Medication

The preoperative prescription of medication described for the abutment-providing modalities in Chapter 9 is also followed for endodontic stabilization cases. Preoperative administration of anti-edema medication is generally not required for mainstream cases, unless the patient's history suggests that edema may be greater than normal. Nor is preoperative sedation recommended. Patients who take prophylactic aspirin daily are advised to discontinue doing so for at least 3 weeks preoperatively, to allow for normal clotting at the insertion visit.

ENDODONTIC STABILIZER IMPLANT INSERTION VISIT

The steps that are performed during the one-visit endodontic stabilizer insertion procedure are shown in Box 19-2.

Confirm That Preoperative Medication Has Been Taken

It is not necessary to postpone the case if the patient has not taken his or her preoperative prophylactic antibiotic medication. The practitioner should have antibiotics on hand for preoperative administration in such cases. If a patient on an aspirin regimen has not discontinued its use, insertion may nonetheless be performed, with delayed clotting expected.

■ Instrumentation Setup—The Armamentarium

The sterile tray setup should include local anesthetic and syringes with appropriate needles; a mirror; an explorer; suction tips; a plastic instrument; a syringe with canal sterilization flush; a selection of large cotton points; a set of graduated hand and/or engine-driven reamers up to size No. 90 or No. 120 for the No. 3 or No. 4 stabilizers, respectively; rubber stoppers; an endodontic contra angle; an endodontic millimeter rule; locking college pliers; a titanium seating wrench (for post-core stabilizers); millimeter x-ray grid; periapical radiograph films; endodontic cement; slow-setting crown and bridge cement; setup to isolate the tooth under treatment; low-speed contra angle; the selected sterilized sta-

BOX 19-2 ■ ONE-VISIT ENDODONTIC STABILIZER IMPLANT INSERTION PROTOCOL

Confirm use of prophylactic antibiotic
Administer local anesthetic
Enlarge canal with tapered reamer
Parallel dentinal walls at apical 4 mm of canal
Prepare implant osteotomy to its final depth
Tap apical 4 mm of canal and osteotomy beyond apex
Insert millimeter measuring rod into osteotomy
Take periapical radiograph to evaluate whether depth of osteotomy can be increased, and to determine location of apex
Flush, sterilize, and dry canal to apex
Apply endodontic cement to portion of stabilizer that will be located within paralleled dentinal walls at apical 4 mm of root following seating
Apply crown and bridge cement to portion of stabilizer that will be coronal to paralleled dentinal walls
Seat endodontic stabilizer implant
Trim excess stabilizer length in oral cavity
Prescribe postoperative medication
Provide home care instruction

bilizer implant; and its coordinated bone drill and millimeter measuring rod (Figs. 19-18 and 19-19).

Sterilization is performed as with all dental treatment instrumentation.

Local Anesthetic and Promotion of Comfort

In the absence of allergic conditions or medical contraindication, local anesthetic with 1:100,000 vasoconstrictor is administered as for conventional endodontic therapy. A loaded syringe is kept available for supplemental administration or to help control bleeding, if necessary.

Expose the Canal for Treatment

The endodontic stabilization protocol for mainstream cases begins when all endodontic therapy has been completed to the point at which the canal is measured for depth and ready for obturation. Isolate the tooth, expose the canal, and flush with sterilizing solution (Fig. 19-20).

Enlarge the Canal

If a No. 3 stabilizer is chosen, progressively enlarge the canal to a No. 90 reamer inserted 2 mm beyond the apex. For the No. 4 stabilizer, enlarge to a No. 120 reamer to the same point 2 mm beyond the apex (Fig. 19-21).

At all times during this phase, exert reaming pressure toward the lingual to enlarge at the expense of lingual bone and preserve the thinner buccal/labial plate. It is advised that only hand instrumentation be used through the No. 25 reamer. Starting with the No. 30 reamer, one may switch to engine instrumentation, if desired.

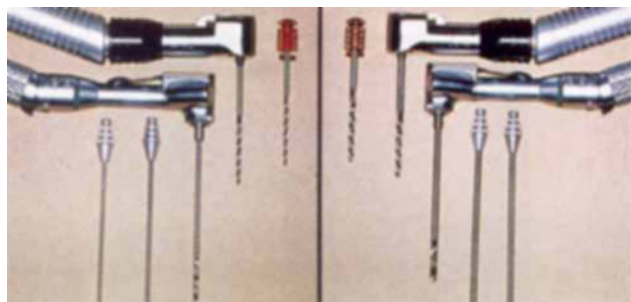


FIG. 19-18 ■ Hand and engine reamers, bone drill, millimeter measuring rod, and stabilizer (No. 3 left, No. 4 right).



FIG. 19-19 ■ Post-core/stabilizer combination armamentarium.

Flush and cleanse often as the series of reamers is used to enlarge the canal to its coordinated final size.

Parallel the Dentinal Walls of the Apical Area

Place the bone drill that coordinates with the size of the stabilizer to be used (in the teaching case a No. 3 for a mandibular incisor) into a low-speed contra angle. Before the endodontic stabilization protocol is begun, at the time of canal instrumentation, a radiograph is taken with a file or reamer in position to determine the distance from the apex to the chosen measuring point on the clinical crown. A rubber stopper is now placed on the bone drill at that distance plus 2 mm, as measured from the tip of the drill. With external coolant, the drill is passed into the canal at low speed until the rubber stopper comes into contact with the measuring point on the crown. This will parallel the apical 4 mm of dentin lining the canal (Fig. 19-22). This also initiates the drilling of the stabilizer osteotomy to a depth of 2 mm beyond the apex.

Because of the standardized taper of the final reamer used to enlarge the canal (No. 90 in the teaching case), the coordinated bone drill first contacts the dentin approximately 4 to 5 mm from the apex. Use gentle, intermittent pressure to pass the drill apically until the rubber stopper contacts the measuring point on the crown. Because the drill is parallel sided, the facing dentinal walls in the apical area are paralleled. The diameter of the drill is slightly wider than the minor diameter of the stabilizer, and narrower than its major diameter.



FIG. 19-20 ■ Canal ready for obturation at start of stabilization protocol.

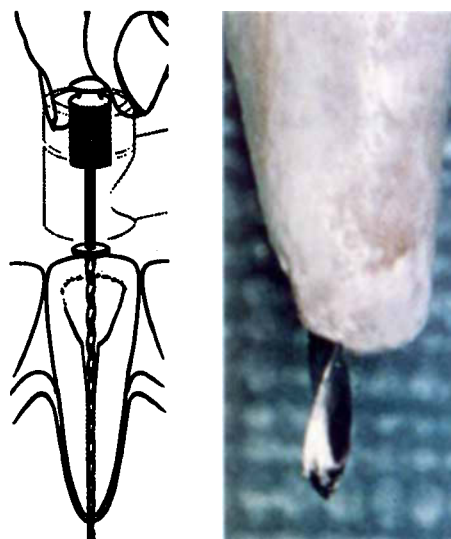


FIG. 19-21 ■ Coordinated reamer penetrating 2 mm beyond apex.

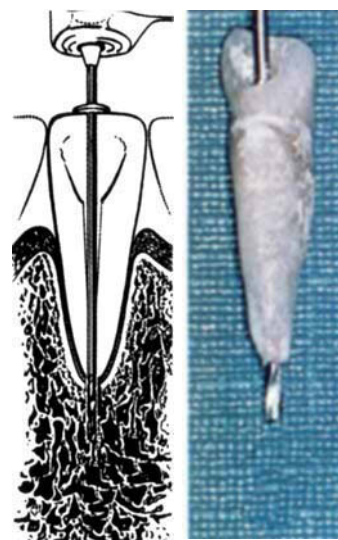


FIG. 19-22 ■ Parallel-sided bone drill penetrating 2 mm beyond apex.

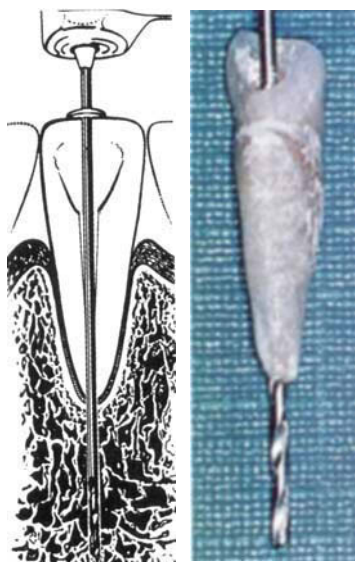


FIG. 19-23 ■ Parallel-sided bone drill preparing osteotomy to planned depth.

Prepare the Stabilizer Implant Osteotomy

Withdraw the drill and cleanse it. Using the preoperative radiograph taken with the millimeter grid as a guide, estimate the number of millimeters of bone from the apex to the cortical plate, and move the rubber stopper coronally to the point that corresponds to that distance from the drill tip, to limit the depth of bone drill insertion in creating the final osteotomy.



The osteotomy is prepared to the opposite cortical plate, unless the presence of an undercut prevents this.

Apply intermittent force apically to prepare the osteotomy to its estimated final depth (Fig. 19-23). Use water spray, and drill at low speed until the rubber stopper comes into contact with the measuring point on the crown of the tooth.



During this procedure, place one finger gently against the labial surface of the bone to confirm by palpation that, as the bone drill prepares the osteotomy, bone perforation does not occur. If a perforation is felt, stop drilling, withdraw the drill approximately 2 mm and move the rubber stopper down to the coronal measuring point on the tooth.

Remove the drill, and record in millimeters the distance from the coronal measuring point to the base of the osteotomy.



Three key measurements have now been recorded: the total distance from the position of the rubber stopper against the coronal portion of the tooth to the base of the osteotomy, the distance to the apex of the root, and by subtracting, the distance from the apex to the base of the osteotomy.

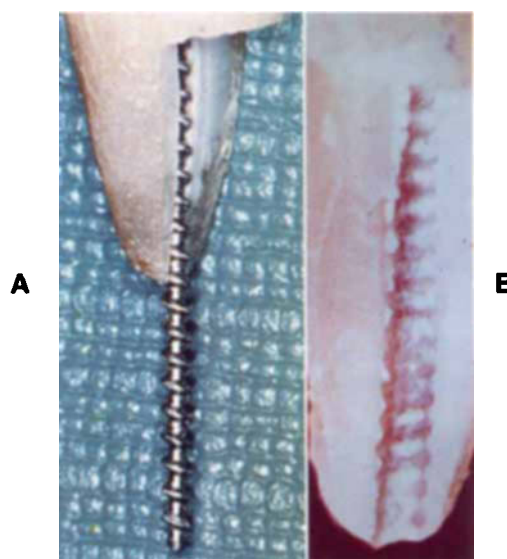


FIG. 19-24 ■ Endodontic stabilizer tapping dentinal walls (A), and threaded dentin (B).

Tap the Parallel Dental Walls and Osteotomy to Its Base

Remove the endodontic stabilizer implant from its pouch. The stabilizer is first used as its own tap, to internally thread the dentinal and osteotomy walls (Fig. 19-24). By hand, begin tapping by gently inserting the stabilizer while slowly turning it clockwise. If binding occurs, turn counterclockwise to remove and cleanse the stabilizer, reinsert it, and repeat the process until the osteotomy has been tapped to its final depth. After the final depth has been achieved, remove, cleanse, and dry the stabilizer.



The stabilizer, when being used as a tap, may bind because of accumulated cut dentin and bone chips clogging the threads. Frequent removal and cleansing of the stabilizer during tapping corrects this.

While tapping, keep a finger on the labial plate of bone to detect a penetration in the unlikely event that tapping progresses out of line with the prepared osteotomy.



Because the diameter of the osteotomy falls between the major and minor diameters of the stabilizer, only the outer half of the threads taps the dentinal walls. This allows space between the dentinal walls and shaft of the stabilizer to guide any endodontic cement expression coronally rather than apically.

Confirm and Adjust Final Depth in Millimeters From Root Apex to Osteotomy Base

Insert the coordinated millimeter measuring rod (No. 3 in the teaching case) to the base of the osteotomy. Set the rubber stopper at the coronal measuring point.

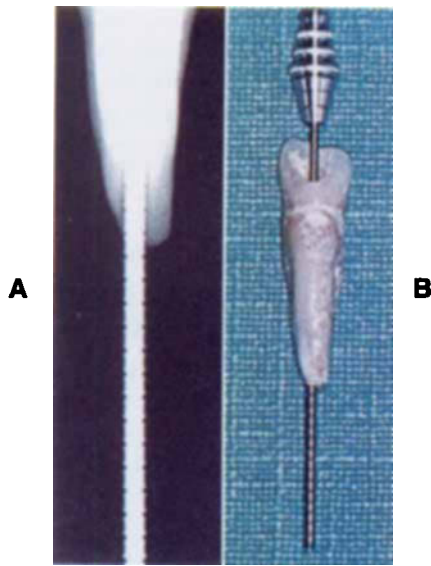


FIG. 19-25 ■ Radiograph (A) of millimeter measuring rod passing through apex (B).

The millimeter measuring rod has a groove at every millimeter of depth. The diameter of the rod is smaller than the diameter of the bone drill to avoid damage to or widening of the prepared and tapped dentinal and osteotomy walls.

With the millimeter measuring rod in position, take a periapical radiograph (Fig. 19-25). The marks on the millimeter measuring rod appear clearly on the radiograph, and allow for precise measurement regardless of any image distortion. Measure and record the distance from the base of the osteotomy to the apex of the tooth by counting the millimeter marks visible on the radiograph. Extraorally measure and record the distance from the stopper to the base of the millimeter measuring rod.

These measurements are not estimates. They are accurate, and are used for the next steps in the procedure. If the radiograph indicates available bone depth beyond the base of the osteotomy, it is possible to deepen the osteotomy to improve the crown/root ratio further when the stabilizer is seated.

Set the bone drill into its low-speed contra angle. Place the rubber stopper at the position on the drill that represents the depth from the measuring point on the crown to the base of the osteotomy plus the additional number of millimeters of available bone according to the millimeter measuring rod radiograph. Drill until the rubber stopper comes into contact with the coronal measuring point according to the protocol previously described. When the osteotomy has been deepened to its planned extent, thread the newly deepened portion using the stabilizer, as previously described.

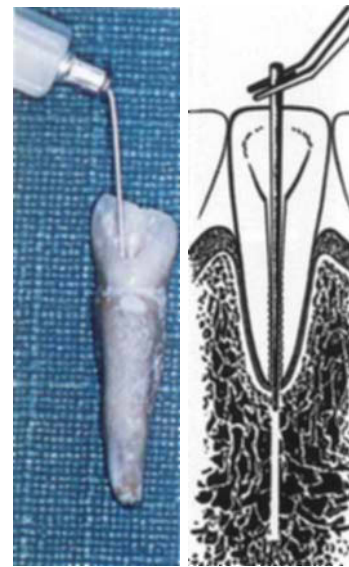


FIG. 19-26 ■ Flushing (A) and drying (B) of canal.

Flush, Resterilize, and Dry Canal

The root canal is now flushed and dried as is conventionally done according to one's favored endodontic therapy protocol in preparation for final placement of the endodontic stabilizer implant (Fig. 19-26).

Flush gently to limit the presence of solution beyond the apex.

If bleeding from the osteotomy persists, deposit local anesthetic containing 1:100,000 vasoconstrictor directly into the osteotomy by passing the needle into the canal and through the apex. Do so slowly and without undue pressure. Next, with a series of extra-large cotton points, dry the canal up to and approximately 2 mm beyond the apex. If seepage continues, press one to three cotton points into the canal and maintain pressure until the bleeding stops. Gently remove them, and insert a few clean cotton points up to but not past the apex.

The canal is now dry and sterile.

Apply Conventional Endodontic Cement to Apical Portion of Stabilizer

Place a rubber stopper on the stabilizer implant. Note the thread that corresponds to the distance from the base of the osteotomy to the apex of the root as recorded on the millimeter measuring rod radiograph (Fig. 19-27). Also note the number of millimeters recorded from the base of the measuring rod to the coronal measuring point, as in-

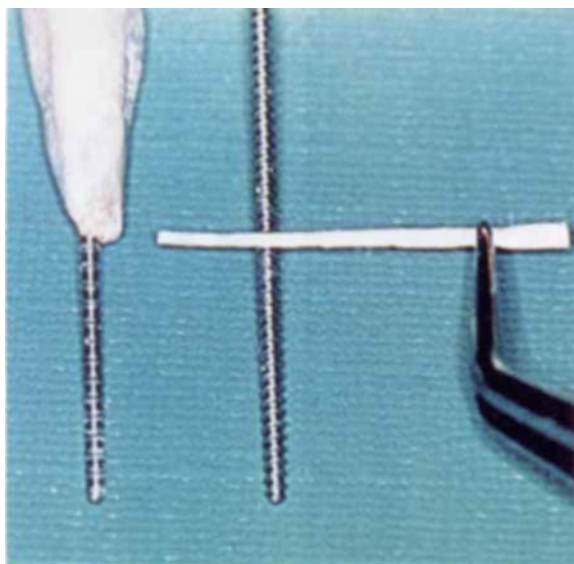


FIG. 19-27 ■ Determination of which stabilizer thread will be at root apex after seating.

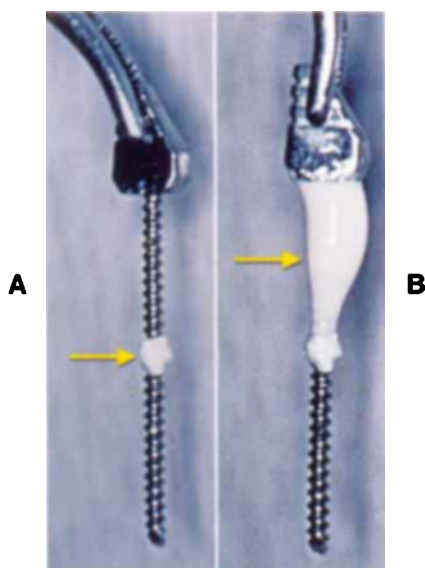


FIG. 19-28 ■ Endodontic cement (arrows) at apex area (A) and crown and bridge cement coronally (B).

indicated by the position of the rubber stopper on the millimeter measuring rod, and move the rubber stopper to the corresponding position on the stabilizer.

The stabilizer seats to the base of the osteotomy. This is equal to the depth to which the millimeter measuring rod was inserted when the measurement radiograph was taken.

Place one's favored endodontic cement for conventional endodontic regimens at the noted apical thread, and cover 4 to 5 mm of stabilizer between that point and the handle (Fig. 19-28).

This endodontic cement seals the apex and fills the threaded dentinal walls. Recall that a space exists between the minor diameter of the stabilizer and the dentinal walls, permitting the expression of excess endodontic cement coronally, and not through the apex when the stabilizer is turned clockwise into position.

Apply Crown and Bridge Cement to the Portion of the Stabilizer Coronal to the Paralleled Dentinal Walls

Apply one's preferred conventional crown and bridge cement to the portion of the stabilizer coronal to the stabilizer area covered with the endodontic cement. The setting time should be slow enough to allow full insertion of the stabilizer at a measured pace.

The portion of the stabilizer covered with crown and bridge cement will not touch the paralleled dentinal walls. Coronal to the apical 4 mm, the tapered walls widen in conformity with the contours of the reamer used to widen the canal (No. 90 in the teaching case). This portion of the prepared canal is wider than the No. 3 stabilizer chosen for the teaching case.

Seat Endodontic Stabilizer Implant to Osteotomy Base

Holding the stabilizer by the handle, gently insert it into the canal. When it meets resistance to vertical seating approximately 4 mm from the apex, turn the stabilizer clockwise slowly and deliberately to engage the threaded dentinal walls.

The tip of the stabilizer, which engages the dentinal threading, is bare. The portion covered with endodontic cement is not yet near the apex of the tooth, and never approaches the osteotomy beyond the apex.

Turn the stabilizer clockwise with gentle apical pressure until it reaches the base of the osteotomy. The endodontic cement is now at the apex, where it creates a seal together with the stabilizer implant threading within dentin (Fig. 19-29).

In cases in which the stabilizer base is close to a cortical plate, the rubber stopper signals to prevent overseating. In most cases in which perforation is not an imminent risk, it is common to seat the stabilizer until it can no longer be turned, when it reaches the osteotomy base.

Postinsertion Radiography

A postoperative periapical radiograph is taken for the patient record (Fig. 19-30).

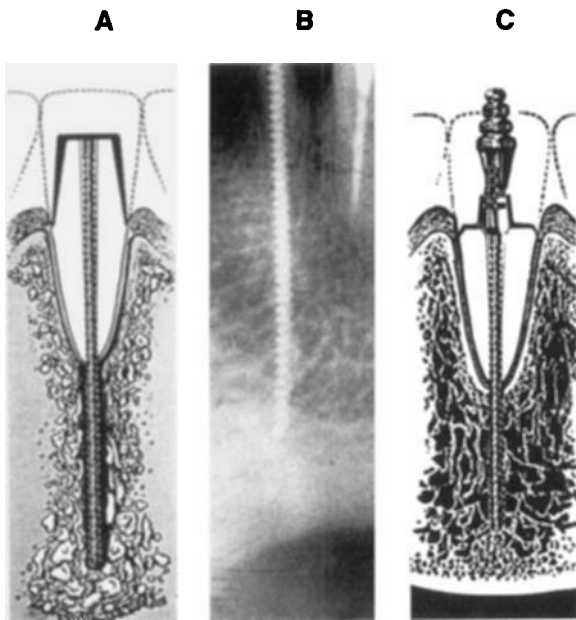


FIG. 19-29 ■ Seated stabilizer trimmed to support coronal tooth structure (A), radiograph of stabilizer seated to cortical plate (B), and post-core/stabilizer seated with hand wrench (C).

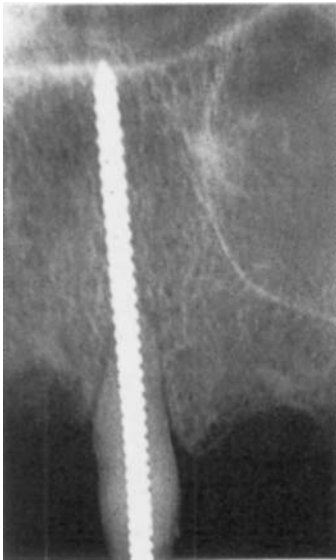


FIG. 19-30 ■ Postoperative periapical radiograph of seated stabilizer.

Note the depth of the stabilizer, the number of millimeters of added length beyond the apex of the root, the area of the apical seal, and the absence of cement beyond the apex.

If the radiograph reveals that the stabilizer was over-seated into a landmark, back it out a few turns, and take another radiograph to confirm that the overseating has been corrected.

Remove Excess Coronal Portion of Stabilizer and Cement, and Check Occlusion

Allow the crown and bridge cement to harden. Remove excess coronal length of stabilizer and its handle using a small, tapered diamond. Remove excess cement. Adjust the tooth to be slightly shy of full occlusion, if necessary.

If the coronal portion of the tooth above the gingival crest is to be maintained, reduce to approximately 2 mm below the occlusal surface to provide room for a restoration. If restoration with a full crown follows, the stabilizer serves to reinforce the remaining coronal portion of the tooth, and is flush with the completed full crown preparation.

Postinsertion Home Care Instruction

Trauma. No medication is needed for postoperative trauma. Postoperative edema is almost never clinically evident.

Prophylactic Antibiotics. Antibiotic medication prescribed preoperatively may be continued for an additional 3 to 4 days after stabilizer insertion, although doing so is not mandatory. One's office policy for antibiotic administration after routine endodontic treatment may be followed.

Comfort Medication. One's office policy for prescribing pain medication after a routine endodontic procedure should be followed. Generally, analgesics are taken only if required.

Diet/Function. The patient is placed on a soft diet and instructed not to chew for approximately 4 weeks on the tooth that was treated. Then, slowly increasing function for 2 more weeks may be followed by full function.

Applied pressure on the treated tooth may reveal tenderness for 3 to 4 days postoperatively. In such cases, which are uncommon, comfort medication should be taken as directed. Transient tenderness of a treated tooth is not a cause for alarm.

Postinsertion Follow-Up Visit

In the absence of complaints, a follow-up visit is usually scheduled 7 to 10 days postoperatively. Asymptomatic cases may be scheduled for restorative procedures at any time following this visit. Restoration should be delayed in the rare cases in which slight tenderness to pressure persists. Prescribing an additional antibiotic regimen now may or may not be indicated, but is usually not required. Tenderness to pressure, in the rare cases in which it persists, usually resolves within 1 or 2 weeks.

Treatment Codes

In conventional stabilizer cases, for purposes of office records and insurance reports, separate the recorded treatment on the patient record into two parts. Record the endodontic therapy, and then record the endodontic stabilizer implant treatment separately. For cases using the unified endodontic stabilizer/post-core combination,

record the post-core procedure separately. Thus, either two or three distinct, separate services have been performed.

PROSTHODONTIC RESTORATION

All common options for prosthodontic restoration are now available for the tooth treated with the endodontic stabilizer implant, with an enhanced prognosis. Because the tooth was originally compromised, it is good practice to splint the tooth to an adjacent tooth or include it within a restoration of greater scope, if possible. Occlusal adjustment is a must.

AFTERCARE AND MAINTENANCE

Special aftercare or maintenance is not required following endodontic stabilization. Commonly recommended general home care and professional maintenance for the completed restorative treatment should be followed. Examination of the stabilizer should be included in all follow-up radiography.

COMPLICATING AND ATYPICAL CONDITIONS

General Frequency of Occurrence

Complications are rare. Success and survival rates of endodontic stabilizers are very high.

Inflammation, Infection, and Periodontal and Endodontic Complications

Inflammation, infection, and periodontal and endodontic complications are treated in the same manner as those related to conventional endodontic therapy. The tooth generally responds more favorably and rapidly to such treatment than if it were not stabilized.

Stabilizer Perforation of Cortical Bone

If it is discovered that the stabilizer extends slightly through a cortical plate postoperatively, and the case is asymptomatic, no treatment is required. If symptoms of tenderness, infection, or swelling occur, expose the area with a gingival flap, and smooth the exposed portion of the stabilizer with a diamond at high speed using coolant. Bone augmentation may be considered.

Root Fracture at the Apex

Because of the precise and coordinated dimensions of the bone drill and endodontic stabilizer, which is used as a tap, root fracture at the apex is very rare. Following the protocol previously described, performing steps slowly and deliberately, and frequently withdrawing and cleansing bone chips from the cutting threads of the stabilizer during tapping prevent this complication. This is a precise, controlled procedure.

The most common cause of root fracture at the apex is an unexpectedly friable root tip, or the use of a No. 4 stabilizer when a No. 3 stabilizer is indicated. If root fracture is noted radiographically and no clinical symptoms are observed, monitor the apex radiographically. If a periapical radiolucency develops, flap the tissue, approach the apex, and curette carefully to remove all soft tissue and possible root fragments from the area. Avoid disturbing the stabilizer, which remains in position during this procedure. Augment if indicated. Prescriptions related to this procedure are the same as those for an apicoectomy.

Paresthesia

No cases of paresthesia have been reported in the literature, and the authors know of none in practice. If a paresthesia were to occur, it would result from overseating a stabilizer that was used in a tooth that should have been avoided in any event. Stabilizers generally are not recommended for teeth in the mandible over the inferior alveolar canal. The possibility of paresthesia in the maxilla is minimal.

VARIATIONS AND ALTERNATIVES

Unified Post-Core/Endodontic Stabilizer Combination

Use of the unified post-core/endodontic stabilizer is appropriate in cases in which the crown of the tooth is compromised to the extent that a post-core is required to aid in restoration. The post-core/stabilizer combination is available in both the No. 3 and No. 4 sizes. Its abutment seats against the faced-off root at or near the height of the surrounding gingival cuff. The case sequencing using the post-core/stabilizer combination is shown in Box 19-3. Departures from the standard stabilizer procedure appear in italicized type.

Creation of an Additional Tooth Root Equivalent

Although the creation of an additional tooth root equivalent is not considered a mainstream procedure, it can be readily accomplished by practitioners who have experience in several mainstream cases. The practitioner penetrates the coronal portion of the tooth root, carefully directing the long axis of drilling to pierce the side of the root at a level a few millimeters apical to the crest of bone, passing into the available bone beyond (Fig. 19-31). This is often done in maxillary second molars to create the equivalent of a new additional tooth root distal to the sinus, high into the tuberosity area. It can also be performed in the last mandibular molar in position to create a new tooth root equivalent under the ascending ramus. This procedure may be performed using available bone in an edentulous area adjacent to any appropriate tooth intended for use as a natural abutment for a conventional fixed bridge, as long as no landmark is impinged upon. The piercing of the tooth root a few millimeters apical to the crest of bone is well accepted physiologically.

BOX 19-3 ■ ONE-VISIT POST-CORE/STABILIZER COMBINATION INSERTION PROTOCOL

Confirm use of prophylactic antibiotic
 Administer local anesthetic
 Enlarge canal with tapered reamer
 Parallel dentinal walls at apical 4 mm of canal
 Prepare implant osteotomy to its final depth
 Tap apical 4 mm of canal and osteotomy beyond apex
 Insert millimeter measuring rod into osteotomy
 Take periapical radiograph to evaluate whether depth of osteotomy can be increased, and to determine location of apex
Remove apical portion of post-core/stabilizer implant at point that corresponds to depth of osteotomy
 Flush, sterilize, and dry canal to apex
 Apply endodontic cement to portion of post-core/stabilizer combination that will be located within paralleled dentinal walls at apical 4 mm of root following seating
 Apply crown and bridge cement to portion of post-core/stabilizer combination that will be coronal to paralleled dentinal walls
 Seat endodontic stabilizer implant until base of abutment is at surface of faced-off root
Prepare abutment if necessary for better parallelism and interocclusal clearance

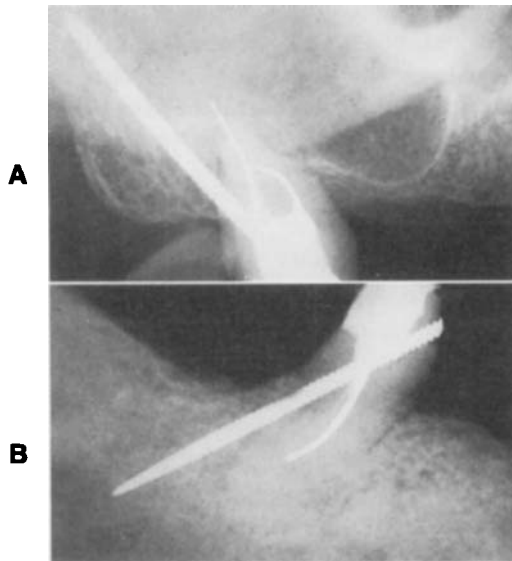


FIG. 19-31 ■ Additional tooth root in tuberosity (A), and distal to third molar in mandible (B).

Endodontic Stabilization of a Fractured Root

Endodontic stabilizers have been used to splint intra-osseous root fractures. This improves the prognosis of the tooth, which otherwise would have been extracted.¹⁰ Although this procedure is not considered mainstream, it can and should be attempted after experience with several mainstream cases.

Smooth, Unthreaded, Parallel-Sided Stabilizer

Experience has shown that the smooth, unthreaded, parallel-sided variation of stabilizer design is contraindicated. Because it is impossible to create a perfect circular hole at the apex during osteotomy preparation, this configuration cannot seal the apex, and tends to cause cement expression beyond the apex during final seating. In addition, the collagen fibers surrounding the stabilizer cannot be stimulated, resulting in an ever-widening fibrous zone around the stabilizer as shown in Fig. 19-4, rather than the osteostimulatory peri-implant ligament that maintains bone close to the interface that forms around a threaded stabilizer.

Tapered Stabilizer

Tapered stabilizers are contraindicated, whether they are threaded or smooth. When smooth, the problems just discussed for smooth, parallel-sided stabilizers all apply. Moreover, tapered stabilizers do not always engage the root at the apex. Most often they bind at a point in the canal that is coronal to the apex, resulting in lack of apical seal. They exert significant lateral force at the point of binding, resulting in a higher incidence of root fracture.

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20 Intramucosal Inserts

Increased Retention and Stability of Maxillary Dentures

BENEFITS AND DESCRIPTION OF THE MODALITY USED IN THE TEACHING CASE

Intramucosal inserts increase the retention and stability of maxillary dentures¹ (Fig. 20-1). Retention is a measure of a denture's resistance to dislodgment, its ability to maintain a suctionlike seal. Stability is a measure of a denture's resistance to movement when its seal is maintained. Much as skin can move across a knuckle, a seated retained denture can show movement in function if some areas of gingiva move freely over bone. Lack of retention is a serious problem for the denture wearer. One's ability to laugh and talk with confidence and to chew without being self-conscious is compromised. These constraints can cause a personality to change, as the wearer fears detection of the denture during normal activities, resulting in less laughter, less talk, and in general less interaction with others. Lack of stability can also compromise confidence, chewing efficiency, and the ability of the wearer to act naturally.

Intramucosal inserts are mushroom-shaped titanium devices affixed to the tissue surface of a maxillary partial or total removable denture. They plug into prepared receptor sites in attached gingiva at the crest and palatal incline, materially increasing the denture's retention and stability² (Fig. 20-2).

Retention is enhanced by engaging tissue in two ways. First, each individual intramucosal insert engages tissue that grows into the undercut area between its **head** and **base**. This tissue, following receptor site preparation, initially heals by epithelialization, followed by **keratinization**³ (Fig. 20-3). Second, the two rows of inserts—typically four on the ridge crest from the cusp extending posteriorly and three on the lingual incline—are each oriented perpendicular to the tissue into which they seat. As a result, the long axes of the inserts in the two rows are at an angle to each other, and therefore a large amount of tissue is engaged between the rows (Fig. 20-4).

Stability is achieved because each insert is seated into attached gingiva. Areas of mobile tissue under the denture base are avoided when selecting receptor site locations for intramucosal inserts, so the denture becomes essentially

immobile.⁴ Receptor sites in attached gingiva can be compressed but cannot be moved across bone to cause instability. The entire denture is secured in position in attached gingiva.

Intramucosal inserts are not effective for treatment to stabilize mandibular dentures. This is because the tissues covering the mandibular ridge are too thin to seat inserts properly, the labial and buccal inclines of the ridge are generally at an angle too acute to the ridge crest to allow for seating, and the tongue has a dislodging effect. Thus, intramucosal inserts are contraindicated in the mandible, although research has been conducted and continues to evolve to overcome this limitation. For example, the concept of intramucosal/**intraosteal inserts** has been explored to make this treatment effective in the mandible (Figs. 20-5 and 20-6).

Prosthodontic Simplicity

The practitioner starts with a well-fitted maxillary partial or total removable denture, adjusted for sore spots and occlusion. Affixing the inserts to the denture, preparing the **gingival receptor sites**, and inserting the denture is performed in one visit, followed by routine follow-up and adjustment. The armamentarium is simple. This procedure can be effectively performed in every dental office as a part of the general practice of routine prosthodontics.⁵

Technique-Permissive Receptor Site Preparation

In a mainstream total denture case lacking sufficient retention and/or stability, such as that shown in the teaching case in this chapter, 14 gingival receptor sites for standard intramucosal inserts are prepared in 5 to 10 minutes. A latch-type No. 3 round bur and a standard tissue receptor site bur are all that are needed. A few drops of local anesthetic containing vasoconstrictor are deposited at each planned gingival receptor site to minimize bleeding and discomfort.



FIG. 20-1 ■ Maxillary denture with intramucosal inserts.

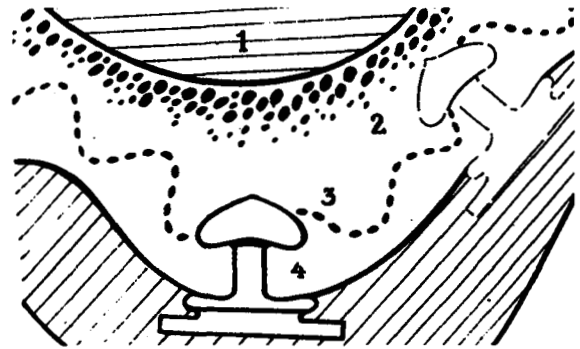


FIG. 20-2 ■ Inserts in their gingival receptor sites showing sinus (1), cortical bone (2), connective tissue (3), and epithelium (4).

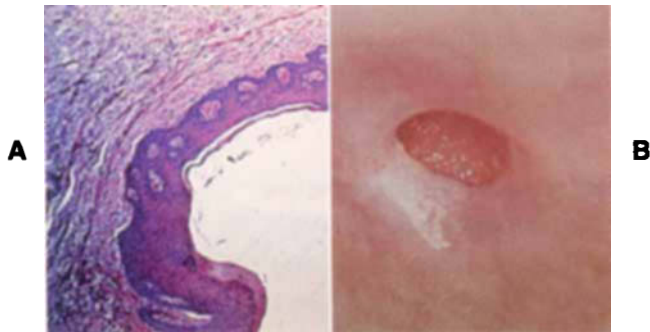


FIG. 20-3 ■ Histology (A) and view of keratinized tissue lining gingival receptor site (B).



FIG. 20-4 ■ Denture showing different axial inclinations of inserts on ridge crest and on palatal incline.



FIG. 20-5 ■ Intramucosal/intraosteal mandibular crestal receptor sites (arrows). (Courtesy Gerhardt Heidelberg, Wurtzberg, Germany.)

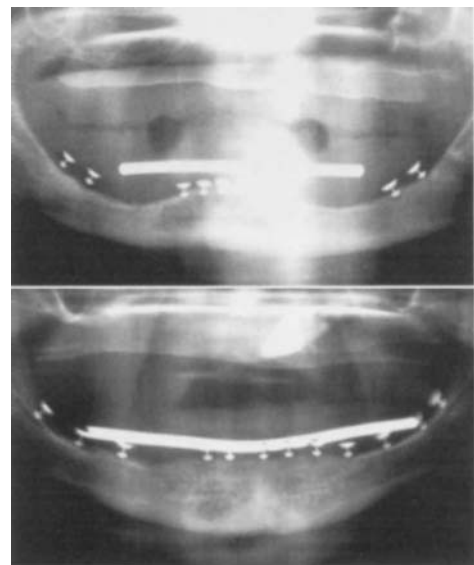


FIG. 20-6 ■ Seated intramucosal/intraosteal inserts in mandible. (Courtesy Gerhardt Heidelberg, Wurtzberg, Germany.)

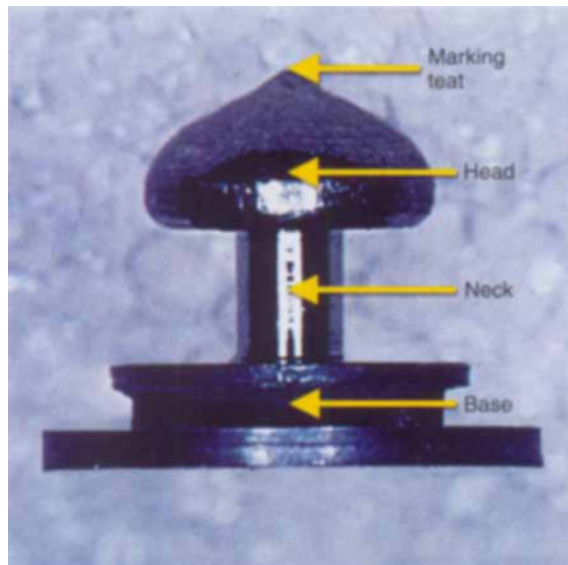


FIG. 20-7 ■ Anatomy of intramucosal insert.



FIG. 20-8 ■ Positioning of disposable nylon protective collar.

Proven Long-Term Success/Survival Rates

It is very rare for an intramucosal insert case to fail or exhibit complications. When a complication does occur, it is almost always localized at a single gingival receptor site. In such cases, the insert is simply removed from the surface of the denture. The insert denture continues to provide increased retention and stability even in the absence of an individual insert. In some cases, the retention and stability is so great that the patient finds it difficult to remove the denture. No case of a growth or tumor has been attributed to intramucosal inserts in the literature in the approximately 40 years that they have been in use.^{6,7}

Also of interest is the fact that insert dentures rarely require relines over time, although the reasons for this are not known. It is postulated that the added stability retards bone resorption under the denture. This is an important benefit of the use of intramucosal inserts.³

Unique Benefits

Intramucosal inserts offer patients a cost-effective service that rapidly and predictably yields new confidence and joy in the use of their dentures.

Experience has shown that the vast majority of patients who have few complaints about their complete maxillary dentures but who agree to treatment with intramucosal inserts are pleased at the unexpected degree of increased stability and functional improvement. In view of this, and also because insert dentures tend not to require relining, the use of intramucosal inserts could be an option offered to all maxillary denture patients, and perhaps in time may become a conventional procedure in maxillary complete or partial removable denture treatment.

Anatomy and Nomenclature of the Intramucosal Insert

Each solid insert has a mushroom-shaped head, with a **marking test** at its apex. The head has sloping sides to permit ease of denture insertion by atraumatically stretching the healed gingival receptor site, which is undercut to promote retention. Under the center of the head, a neck extends down to the base of the insert. The length of the neck controls the depth of insertion of the head into gingival tissue. The base promotes firm attachment of the insert when it is affixed into its prepared acrylic receptor site within the tissue surface of the denture (Fig. 20-7). The base has two flanges of different diameters. Each insert is supplied with a protective disposable **nylon collar** (Fig. 20-8) that precludes the insert cementing medium, usually self-curing acrylic, from expressing into the undercut area under the head when the insert is affixed to the tissue surface of the denture.

DIAGNOSIS, TREATMENT PLAN, AND END RESULTS

Case as Presented

Patient's Story. The patient's chief complaint is dissatisfaction with his or her ability to function with a maxillary denture. The current denture may not be the patient's first. It moves or unseats during eating, and is sometimes unstable when the patient laughs or talks. The patient may be irritable or depressed, and is exasperated with the situation.

Clinical Appearance. Clinically, one observes a well-made denture, often one fabricated in the practitioner's own office. The fit and flange extensions are fine. The denture is relieved to clear the frena. There is a proper post-dam area. No sore spots are observed. The occlusion is correct. The denture is flattering esthetically.

Although a few areas of gingival tissue that are less than firm may be present, by and large an adequate amount of attached gingiva exists along the ridge crests and their lingual inclines, especially from the cuspid areas distally. The saliva is normal, sometimes serous, and rarely ropy or mucinous.

In many cases, the anatomy of the ridges is adequate to support a complete denture with ease. In others, the anatomy is less adequate, and is probably the primary cause of the problem. In some cases, the musculature is overdeveloped, possibly aggravated by a habit that together with the musculature tends to unseat the denture. Sometimes the patient subconsciously cannot accept the concept of wearing a complete denture, and may have complaints about problems that other patients would barely notice or not consider particularly bothersome. Gagging may be a problem.

Radiographic Interpretation. The pretreatment radiography can reveal a range of presentations, all of which can be approached with mainstream intramucosal insert treatment. One may observe ample available bone, or almost none. Careful inspection of the radiographs reveals a rather thick, dense layer of soft tissue over the bone. It is into this tissue that each insert will be seated within its gingival receptor site.

Rejected Alternative Treatment Plans

The patient has been offered all implant dentistry options. Appropriate endosteal and/or subperiosteal implant options were described in detail. One or several considerations led to the rejection of treatment using an abutment-providing implant modality. Treatment would take too much time, or the patient prefers to undergo a less invasive procedure, or there was previous treatment with one of the abutment-providing implant modalities that either served the patient well for a number of years, or never solved the patient's problem. Perhaps health considerations contraindicate the use of abutment-providing implants at this time, or the age of the patient is too advanced, or the patient has financial constraints. Fabrication of another denture is also ruled out as a final solution to the patient's problems. In mainstream cases such as the teaching case, the existing denture tends to be in fine condition. If not, a new denture is fabricated and adjusted before intramucosal insert treatment.

Accepted Treatment Plan—Single-Visit Case Sequencing

The case is diagnosed for treatment using intramucosal inserts to improve retention and stability of the existing maxillary denture. This procedure requires one treatment visit that can usually be performed in approximately 1 hour of scheduled time.

Completed Case

Having the goal firmly in mind during treatment is important. The end result is presented here to help the reader

BOX 20-1 ■ PREOPERATIVE PROCEDURES

Fabricate edentulous model of maxilla
Mark ideal insert locations on model
Prescribe prophylactic medication, if necessary

understand how each step of treatment contributes to the final objective, and to convey the satisfaction and benefits of treatment both for the patient and practitioner.

Patient's Story. The treatment goal has been achieved. The denture shows a substantial increase in retention and stability. The patient can now eat, laugh, talk, and socially interact with greater confidence and pleasure. Fine home care is easy to maintain.

Clinical Appearance. The denture is esthetic and functional. After healing, gingival receptor sites are lined with keratinized tissue.

PLANNING AND PROCEDURES BEFORE INSERT DENTURE INSERTION

The steps that are performed before the intramucosal insert treatment visit are shown in Box 20-1.

Fabricate an Edentulous Study Model of the Maxilla

When the maxillary denture to be used is ready, either via fabrication of a new denture or relining and adjustment of an existing denture if required, an edentulous study model of the maxilla is fabricated. This model is used to record the condition of the overlying tissues as observed during clinical examination, and for planning of gingival receptor site locations.

Mark the Ideal Locations of the Gingival Receptor Sites on the Model

The ideal locations of the gingival receptor sites are marked on the edentulous study model (Fig. 20-9) based on a thorough clinical examination of the overlying mucosa. First, record any areas of flabby and/or unattached gingiva that may exist in areas targeted to receive intramucosal insert gingival receptor sites on the study model.

In the teaching case, 14 standard intramucosal inserts are used. Four insert locations are marked on the crest of the ridge on each side of the study model, starting at the cuspid area and progressing distally at regular intervals to the height of the tuberosity. Next, three receptor site locations are marked on the lingual incline of each ridge. Each lingual incline receptor site is located between two crestal inserts, forming equilateral triangles. Inserts are not placed along the posterior border of the denture, nor are they usually placed on the ridge crest or lingual incline anterior to the cuspids. Along the posterior border, the tissue is too



FIG. 20-9 ■ Study model with marked gingival receptor site locations (*black circles*) and flabby tissue unsuitable for use (*dotted line*).

vascular and tender—not as keratinized—and anteriorly the crest is often too flabby and the lingual incline too steep.

During the initial examination, the areas of flabby or unattached gingiva are marked on the study model, as shown in Fig. 20-9. The presence of such areas is uncommon, but when encountered, they are important to record. Inserts should not be placed in flabby or unattached gingiva. Therefore, insert dentures are occasionally fabricated with 11 to 13 inserts, rather than the conventional 14, if an area targeted for insertion exhibits flabby tissue.

Mainstream cases do not present with inflamed, sore gingiva. If a patient presents with such a condition, the conventional soft-tissue treatment favored in one's office is performed. When such treatment is complete, resulting in healthy gingival tissues, the intramucosal insert protocol is initiated.

Prescribe Preoperative Prophylactic Medication, If Necessary

Prophylactic antibiotic medication is only recommended if, in consideration of the patient's general health and history, the practitioner deems it advisable. For most patients, preoperative antibiotic coverage is not necessary. Patients who take prophylactic aspirin daily are advised to discontinue doing so for at least 3 weeks preoperatively, to allow for normal clotting at the insertion visit.

Postoperative edema is usually not observed, and therefore does not require special consideration preoperatively. If it does occur, it is almost always minor, and not visible. The denture, which is seated firmly over the newly created gingival receptor sites, acts as a stent to minimize swelling by compressing the tissues. The soft palate and uvula may experience slight edema, which will bother the patient during swallowing for a few days. Inform the patient of this likelihood. No medication is required to counteract

BOX 20-2 ■ ONE-VISIT INTRAMUCOSAL INSERT TREATMENT PROTOCOL

Confirm use of prophylactic antibiotic, if prescribed
Mark each acrylic receptor site location on tissue surface of denture
Prepare acrylic receptor sites in tissue surface of denture
Affix intramucosal inserts to denture, trim, and polish
Mark locations of planned gingival receptor sites on maxillary mucosa
Administer local anesthetic
Prepare gingival receptor sites
Test seat denture with inserts
Adjust for accuracy of seating of inserts within gingival receptor sites
Perform final seating of insert denture
Check occlusion, initial retention, and initial stability
Prescribe postoperative medication
Provide home care instruction

this edema, which recedes naturally within a few days postoperatively.

INSERT DENTURE INSERTION VISIT

The steps that are performed during the one-visit intramucosal insert denture insertion procedure are shown in Box 20-2.

Confirm That Preoperative Medication Has Been Taken

Preoperative medication is generally not required in mainstream cases. If prophylactic antibiotic was prescribed but not taken, it is usually not necessary to postpone the case. The practitioner should have antibiotics on hand for preoperative administration in such cases. If a patient on an aspirin regimen has not discontinued its use, insertion may nonetheless be performed, with delayed clotting expected.

Instrumentation Setup— The Armamentarium

The inserts and their protective collars are not part of the tray setup. They are placed on a separate laboratory tray, together with a No. 3 straight handpiece round bur, a straight handpiece **acrylic receptor site bur**, an acrylic receptor site testing instrument, a tube of cyanoacrylate cement, a dappen dish with pink quick-cure polymer, another dappen dish with quick-cure monomer, a straight brush, a soft Robinson bristle brush, a straight handpiece **acrylic trim bur**, a needle holder, college pliers, a few gauze squares, and alcohol. This tray setup is used in the laboratory to attach the inserts to the denture.

The sterile tray setup for clinical use consists of a mirror, an explorer, a low-speed contra angle, a No. 3 latch-



FIG. 20-10 ■ Standard insert armamentarium.

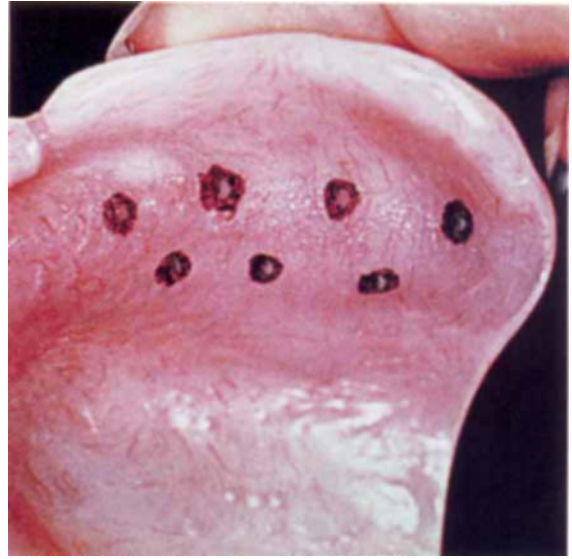


FIG. 20-12 ■ Marked and scored receptor site locations.



FIG. 20-11 ■ Large insert armamentarium.

type round bur, a tissue receptor site bur, local anesthetic containing 1:100,000 vasoconstrictor, povidone-iodine (Betadine), an indelible tissue marker, a tissue receptor site testing instrument, and gauze squares. The specialized standard insert (Fig. 20-10) and large insert (Fig. 20-11) bur sets are illustrated.

Mark Each Acrylic Receptor Site Location on Tissue Surface of Denture

The receptor site locations are carefully marked on the edentulous maxillary study model, as shown in Fig. 20-9. In the office laboratory area, using the study model as a guide, mark the corresponding receptor site location directly on the tissue surface of the denture with an indelible pencil (Fig. 20-12). Check for accuracy. At the center of

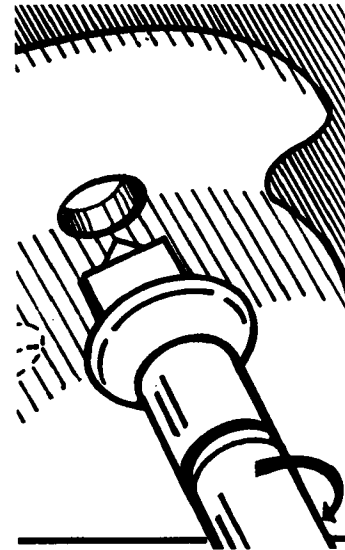


FIG. 20-13 ■ Acrylic receptor site bur held perpendicular to tissue surface of denture.

each planned acrylic receptor site, drill a score mark into the acrylic using a No. 3 round straight handpiece bur.

This score mark records each acrylic receptor site location and acts to stabilize the acrylic receptor site drill when it is used. In preparing the final score marks, check again that all receptor sites, if connected by lines, would form equilateral triangles. This ensures ideal spacing when tissue conditions permit, as they almost always do in mainstream cases.

Prepare Acrylic Receptor Sites

Place the acrylic receptor site bur into the score mark closest to the cuspid on the ridge crest. Hold the long axis of the bur perpendicular to the tissue surface (Fig. 20-13).



FIG. 20-14 ■ Completed acrylic receptor sites.



FIG. 20-15 ■ Inserts with protective collars in position.

The center point of the cutting edge of the bur nests within the score mark to stabilize the bur during cutting.

At a moderate speed, with gentle downward pressure, prepare the acrylic receptor site. Stop and cleanse as required during the procedure.

Watch the safety stop of the bur. This large, smooth area controls the depth of the acrylic receptor site to coordinate it with the depth of the insert base. When this bur is properly used, it is not possible to make the acrylic receptor site too deep. Stop drilling when the safety stop contacts the tissue surface of the denture.

Moving distally, complete the three remaining crestal acrylic receptor sites. Prepare the four crestal acrylic receptor sites on the opposite side according to the same procedure.

Always keep the long axis of the acrylic receptor site bur perpendicular to the tissue surface. This ensures that the four crestal inserts will be parallel.

Now prepare the three lingual incline receptor sites on each side. Start anteriorly, holding the long axis of the acrylic receptor site bur perpendicular to the tissue surface on the incline. Complete the preparation of all of the lingual acrylic receptor sites according to the procedure described for the crestal sites (Fig. 20-14).

Test each acrylic receptor site for completion using the acrylic receptor site testing instrument. Place it into each site. Its tip is the same shape and size of an insert base. This allows visualization of how each insert base will seat into its acrylic receptor site.

Confirm that the base of each insert will seat properly, and that the upper flange of the base will be flush with the denture tissue surface. If not, deepen the receptor site.

Affix the Intramucosal Inserts to the Denture

Place the nylon protective collars onto the inserts. With college pliers, seat each insert into position on the ridge crest of one side of the denture. Tease them parallel to one another. Remove the most anterior insert, and apply a drop of cyanoacrylate cement into its receptor site to hold the insert steady during the final affixation process. Reseat the insert with its protective collar. Repeat this procedure for each subsequent insert, proceeding distally. Wait until the cement hardens (Fig. 20-15).

Tease the inserts parallel to one another as each is seated with initial retention cement. This step prevents an insert from being affixed at a less-than-ideal angle.

Dip a straight sable brush into the self-cure monomer, and then into some polymer to pick up a small mix on the tip. Apply the mix at one area around the base of the insert, and let it harden (Fig. 20-16). After hardening, apply self-cure acrylic around the entire base of each insert.

Note that the upper flange of the base has a smaller diameter than the lower flange. The acrylic flows into the space between the upper flange and the denture to seal the insert into position. The protective collar prevents acrylic from getting into the area of the neck of the insert, where it would be very difficult to remove. Apply the sealing acrylic carefully, to minimize excess.

Repeat this insert cementing procedure for the four crestal inserts on the opposite side, and then for the three lingual incline inserts on each side. The denture may be placed into hot water to hasten the hardening of the pink self-cure fastening acrylic.

After the acrylic hardens, grasp and lock onto the upper 2 mm of the nylon protective collar over an insert using a needle holder. Rapidly pull the collar away from the insert in the direction of its long axis to remove the nylon protective collar without disturbing the insert. Remove each of the remaining protective collars in the same way.

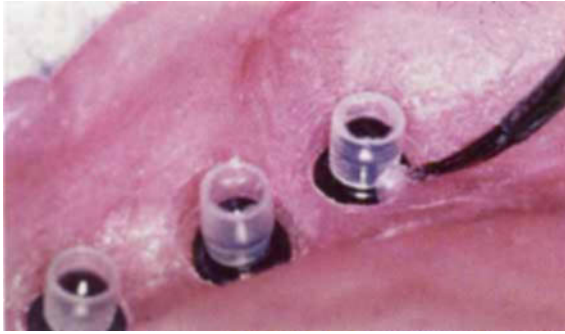


FIG. 20-16 ■ Initial phase of cementation with self-cure acrylic.

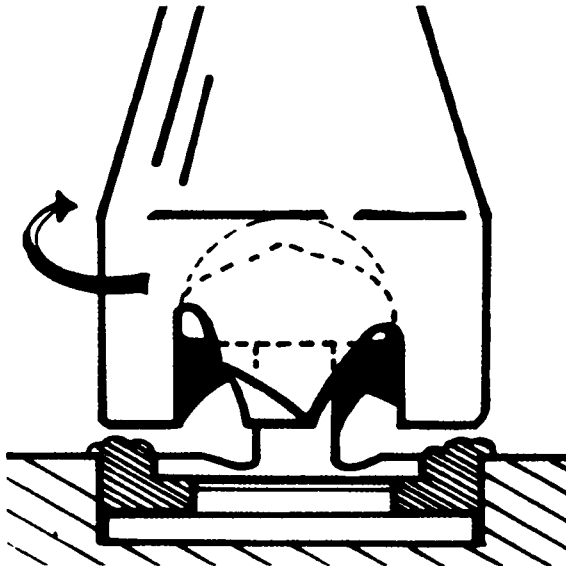


FIG. 20-17 ■ Proper positioning of acrylic trim bur over insert.

One can now understand the value of the protective collars. Hardened excess acrylic is clearly visible around the base, but no acrylic is present around the neck or on the underside of the mushroom head.

Trim excess acrylic with the acrylic trim bur. Pass the trim bur over the head of each insert at low speed without water coolant. Hold its long axis parallel to the long axis of the insert, and press toward the base until the cutting edge of the bur cleans the top flange of the base (Fig. 20-17). Repeat this process for each insert, brush away debris, and inspect for any areas of excess acrylic that cannot be removed using the acrylic trim bur.

The acrylic trim bur is designed to pass over the head of the insert with adequate clearance to prevent binding. Its cutting edge is shaped to permit visibility at the point of trimming, to facilitate accuracy. The removal of excess acrylic is limited by contact between the trim bur's cutting edge and the metal rim forming the top flange of the insert.



FIG. 20-18 ■ Polishing of seated inserts.



FIG. 20-19 ■ Completed insert denture.

With a No. 3 round straight handpiece bur, carefully trim away any excess acrylic that remains after use of the acrylic trim bur.

Move this bur rapidly to leave a smooth, semi-polished area of trimmed acrylic.

Cleanse the Denture

Using a soft Robinson bristle brush at low speed, polish all the acrylic between and around the inserts (Fig. 20-18), and reinspect to be sure no excess or debris remains. Scrub the denture, wash, and dry (Fig. 20-19). Before placing the denture on the chairside tray setup, wipe it liberally with gauze squares soaked in alcohol, and rinse.

The laboratory portion of the procedure is now complete.



FIG. 20-20 ■ Teats marked with indelible pencil.



FIG. 20-21 ■ Insert impressions indicating tissue receptor site locations.

Preoperative Tissue Preparation

Apply povidone-iodine to the entire maxillary edentulous area and surrounding tissues.

Mark the Receptor Site Locations on the Maxillary Tissue

When marking the receptor site locations on the maxillary tissue, start with the four crestal inserts on the right side. Using a gauze square, dry the right ridge crest. Insert the denture and apply direct pressure to dimple the gingiva with the inserts, or mark each insert on and around its marking teat using an indelible blue marking pencil (Fig. 20-20).

Drying the gingiva facilitates the transfer of the marking medium onto the planned gingival receptor sites.

Seat the denture carefully, and have the patient bite down firmly in centric occlusion for about 30 seconds to transfer the insert location markings to the gingiva.



FIG. 20-22 ■ Local anesthetic administered at center of each planned receptor site.

This step may be uncomfortable for the patient.

Local Anesthetic, Promotion of Comfort, and Control of Bleeding

Remove the denture carefully. Marks that correspond to the positions of the inserts on the denture are visible on the right ridge crest (Fig. 20-21), equally spaced between the cuspid area and the height of the tuberosity. Deposit a few drops of anesthetic containing 1:100,000 vasoconstrictor directly in the center of each mark (Fig. 20-22).

The anesthetic is used to control discomfort and bleeding during receptor site preparation.

Mark Each Tissue Receptor Site

Using a No. 3 round latch-type bur in a low-speed contra angle, penetrate the tissue at the exact center of each mark, the same point at which the anesthetic syringe needle penetrated the tissue (Fig. 20-23). Wipe away the marking medium.

The penetration acts as a clear, nonremovable landmark to locate each planned gingival receptor site. Repeat these steps for left ridge crest inserts, followed by the right and left lingual incline areas. With all of the intramucosal insert locations marked and anesthetized, the gingival receptor sites can be prepared. A few additional drops of anesthetic may now be administered at each site. The patient should feel little or no discomfort as this anesthetic is administered.

Prepare the Intramucosal Insert Tissue Receptor Sites

The latch-type tissue receptor site bur is placed in a low-speed contra angle. Coolant is not used.



FIG. 20-23 ■ Gingiva penetrated with No. 3 round bur to mark receptor site locations.



FIG. 20-25 ■ Gingival receptor site bur with safety stop (arrow).

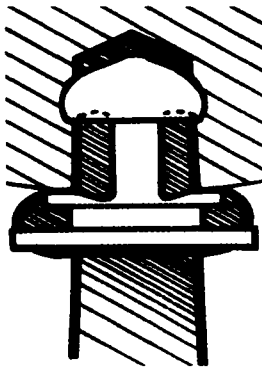


FIG. 20-24 ■ Receptor site bur (shadowed) is narrower and deeper than insert.

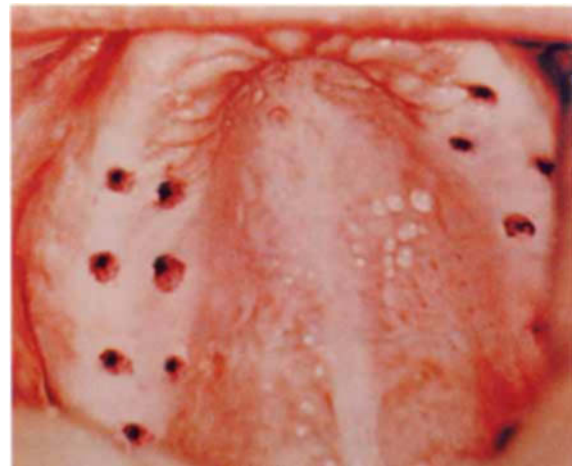


FIG. 20-26 ■ Gingival receptor sites prepared to final depth.

The design of the tissue receptor site bur is unique. It is smaller in diameter than the mushroom head of each insert (Fig. 20-24). This provides a degree of frictional fit on the day the denture is seated, although healing has not yet begun. The bur cuts the tissue receptor site deeper than the distance from the insert base to the apex of the insert head. This additional space, which initially fills with a blood clot, helps to preclude pain while the patient clenches in centric occlusion as hard and as long as possible for a few days postoperatively. This clenching compresses tissue. The bur is provided with a safety stop to prevent overdrilling of gingival receptor site depth (Fig. 20-25).

Hold the long axis of the bur perpendicular to the tissue surface, centered on the penetration mark, and prepare the tissue receptor site until the safety stop contacts the gingiva (Fig. 20-26). Use firm pressure at a low speed without coolant. Test each receptor site with the insert head testing instrument, and redrill if required.

This procedure is performed for every tissue receptor site, area by area. Bleeding is usually minimal. If bleeding persists at any gingival receptor site, a few more drops of anesthetic with vasoconstrictor and direct pressure with a damp gauze square quickly controls it.

Seat the Insert Denture

Cleanse the tissues. Seat the denture by hand, moving it superiorly and into position. It is important to ensure that the seating is firm. Once seated, have the patient close firmly into centric occlusion for 5 minutes. Visually inspect to be sure that the occlusion is in fact in centric (Fig. 20-27). If not, position the denture properly, and have the patient close firmly again.

The firm upward seating squeezes the inserts into the narrower gingival receptor sites.

FIG. 20-27 ■ Seated insert denture in proper occlusion.

Remove the Denture and Check for Accuracy of Insert Receptor Site Placement

The denture is now slowly and carefully removed. Rinse the denture, and wipe the tissues with damp gauze squares. Carefully inspect all the tissues around each receptor site. Examine carefully to determine if there is a deep depression in tissue near a receptor site.

If a deep depression is present, the gingival receptor site for that insert is incorrectly located. If so, follow the complete regimen to make a new gingival receptor site at the location of the observed depression. With the new receptor site completed, reseat the denture for 3 to 5 minutes again, remove, and reinspect. The misplaced gingival receptor site that was prepared initially will heal uneventfully.

Final Seating and Radiography

When the gingival receptor sites are confirmed to be positioned correctly to receive each insert, seat the insert denture firmly into position. The patient is instructed to stay closed firmly in centric occlusion for the next several hours, with as little movement as possible. The patient may alternate between firm and gentler pressure, and may open when necessary to relieve the muscles, but should stay closed with no movement to the extent possible.

Staying closed firmly in centric occlusion for several hours promotes blood clot formation around each insert, to initiate healing.

A radiograph is taken for the patient record.

IMMEDIATE POSTTREATMENT HOME CARE INSTRUCTIONS

Trauma

No medication for edema is required. The patient may experience some discomfort when swallowing for a few days postoperatively.

Prophylactic Medication

Antibiotic treatment may be initiated or continued, if deemed necessary by the practitioner. It is usually not required.

BOX 20-3 ■ FOLLOW-UP SCHEDULE AND PURPOSE OF EACH VISIT

Follow-up visit 1, week 1 to 2: Check occlusion and perform prophylaxis. Check comfort of denture.

Follow-up visit 2, weeks 2 to 4: Prophylaxis, denture removal and reinsertion. Increasing function instruction.

Follow-up visit 3, weeks 4 to 6: Denture removal and reinsertion. Increasing function instruction.

Comfort Medication

Prescribing medication to alleviate discomfort according to one's customary office regimen for postextraction or endodontic treatment is usually sufficient for intramucosal insert treatment.

Cleanliness

It is advised that the patient not remove the denture for any reason for 2 weeks postoperatively. Starting 12 to 18 hours after treatment, the patient may gently rinse with a warm saltwater solution. Gentle brushing with a soft-bristled brush and toothpaste without removal of the denture is permitted.

Diet/Function

A soft diet is essential for at least 2 weeks. During healing, movement should be avoided. The less movement that occurs, the tighter the grip of the tissues around and among the inserts will be, and the greater the ultimate retention and stability.

General Considerations

Postoperative Follow-Up Visits. The schedule and purpose of each follow-up visit are shown in Box 20-3.

The first postoperative follow-up visit is generally scheduled 7 to 14 days after seating of the insert denture. The patient should not remove the denture before the follow-up visit, movement should be limited, and diet should be

restricted to soft foods. By the time of the follow-up visit, the blood clot surrounding each insert has organized. Gingival epithelial cells have migrated around the entire insert head and neck, but the tissues are still fragile. In fact, the tissues are so fragile that removal of the denture at this time can tear valuable, functional tissue. The patient is examined to ensure that centric occlusion is routinely observed on closing. General prophylaxis is performed as required. The next recall visit is scheduled in 7 to 14 days. Home care instructions are reiterated.

At the next recall visit, 14 to 28 days after insert denture insertion, the denture is removed and cleansed. Most often the patient has performed adequate home care. Consider that most of these patients have prior experience wearing a maxillary complete denture. It is recommended that the patient remove the denture, because he or she can determine the path of least resistance and greatest comfort for removal. Removal may be uncomfortable. The tissue is not yet keratinized from long-term function. Only rarely need the practitioner remove the denture. When this is the case, the patient is usually a new denture wearer.

Place a liberal amount of topical anesthetic paste or gel on a gauze square. Immediately following removal of the denture, wipe topical anesthetic into each healing gingival receptor site. Although it is impossible to anesthetize the tissues topically to make the initial denture removal more comfortable, topical anesthetic is applied to make the reinsertion more comfortable. Before wiping the tissues clean with damp gauze squares, permit enough time to elapse to ensure that the topical anesthetic has taken effect. During this wait, the denture is thoroughly scrubbed, and topical anesthetic is placed on each insert head. This acts as a lubricant to ease the denture back into the receptor sites, which need to be stretched open to accommodate the inserts. Following cleansing of the tissues with damp gauze, wipe more topical anesthetic into each receptor site. Wait a few minutes, and then have the patient reseat the denture. Again, it is best if the patient does this. Patients can feel their way, avoid as much discomfort as possible, and sense when the denture is seating properly.

With the denture resealed, patients gain confidence that they can indeed remove and replace the denture. However, at this time, urge them not to do so. A bit more function is now permitted. Request that the denture not be removed until the next recall visit, which is scheduled in 2 weeks. Home care instructions are reiterated.

At the next follow-up visit, ask the patient to remove the denture once again. Healing is now well advanced. It may remain difficult to remove the denture. Patient confidence in denture removal and reinsertion should be high after this visit.

The patient is placed on a routine 3- to 4-month recall program, and advised to remove his or her denture for cleansing as needed. Some patients feel they must do this every day, and some cleanse their dentures weekly. Almost no untoward results occur, whatever the cleansing schedule. Insert dentures rarely require relines, long-term.

COMPLICATING AND ATYPICAL CONDITIONS

Inflammation of a Gingival Receptor Site

Although more common than other complications, inflammation of a gingival receptor site nonetheless is only rarely observed. Its prime cause is excessive lack of parallelism between the affected receptor site and the others. In such cases, with each removal and reinsertion of the denture, tissue is damaged, and chronic inflammation results. Another reason may be that the affected receptor site is in tissue that is too friable or thin. Whatever its etiology, grind off the insert until the stem is flush with the tissue surface of the denture, and polish. Do not replace the insert. The remaining inserts are sufficient to provide retention and stability of the denture.

Lack of Attached Gingiva and/or Excessive Flabby Tissue

Lack of attached gingiva and/or excessive flabby tissue are unusual preoperative presentations that make the intramucosal insert treatment non-mainstream. When these situations occur, the areas marked as unusable on the edentulous study model are extensive enough to limit how many inserts can be used in acceptable areas. In such cases, add additional inserts on the crest of the ridge between the cuspids, but not on the lingual incline. Such insert dentures are sometimes uncomfortable, and have a more guarded prognosis. Excessive flabby tissue can be removed, and following healing, tissue conditioning, and relining of the denture in the treated area, inserts may again be considered.

Insufficient Retention and/or Stability Following Treatment

In rare cases, treatment yields insufficient change to satisfy the patient. If the cause is poor healing or widened receptor sites as a result of too much movement during healing, it is best to remove all the inserts, reline and adjust the denture, and start over. Patient cooperation is a must.

If all the healing seems acceptable, and retention and/or stability still is lacking, add inserts on the ridge between the cuspids. This increases the potential for discomfort, and a more guarded prognosis is expected.

Excessively Acute Palatal Incline From the Ridge Crest

Use of intramucosal inserts in cases that have an excessively acute palatal incline from the ridge crest results in great difficulty in removing and reseating the denture. Often there are inflamed receptor sites. Remove the offending palatal incline inserts and, where room permits between the inserts on the posterior ridge crest, add additional inserts, or if tissue thickness permits, add large-sized inserts. Use of the large inserts is discussed under Variations and Alterations later in this chapter.

Excessively Thin Mucosa

When inserts are used in a maxilla that has excessively thin mucosa, the chief complaint is discomfort on pressure. The tissue receptor site bur cuts the receptor site deeper than the depth of the insert. In cases of thin tissue, when drilling the receptor site, the tissue receptor site may encounter bone before its safety stop contacts the gingival epithelium. In such cases, press firmly to drill away sufficient bone to allow for insert clearance. Epithelium will migrate to line the entire receptor site upon healing. If a receptor site was not drilled deep enough in a case with thin mucosa, leave the inserts in position in the denture, redrill the affected receptor site to its proper depth, and follow the protocol through healing again.



FIG. 20-28 ■ Insert denture with labial flange removed.

Habits That Tend to Dislodge the Denture

Mainstream intramucosal insert treatment is not indicated for patients who have habits that tend to dislodge the denture, because too much movement occurs during healing. Treatment should only be attempted in such cases after experience with several mainstream cases. Although the prognosis is more guarded, these patients need insert treatment the most, and every effort should be made to help them.

Gagging

Historically, gagging was the prime reason for the development of intramucosal inserts. Often the added retention and stability is so great that the entire palate can be removed from the denture. A patient who tends to gag with a seated maxillary denture must be informed that the inserts are used to enhance retention and stabilization, and the patient should be monitored with a conventional intramucosal insert denture. Palatal material is removed only if necessary. Clinical experience has shown that gagging almost always stops when the denture is stabilized, without the need for removal of the palate.



FIG. 20-29 ■ Intraoral views of seated insert denture with labial flange removed. Note relationship with underlying tissue.

Esthetics That Require Removal of the Labial Denture Flange

Some patients have a very thin upper lip, and a denture flange makes it look swollen. With the flange removed, and the anterior teeth of the denture ridge lapped in the same way that fixed bridge pontics would be, the problem can be solved if intramucosal inserts are used to compensate for lost retention and stability (Figs. 20-28 and 20-29).

Closure of Tissue Receptor Sites

Patients must be told before treatment that they should wear their denture at all times. The denture may not be removed at night. If a denture is removed for as little as 4 hours, its receptor sites can close to the extent that denture reseating may be impossible (Fig. 20-30). If this oc-

curs, the receptor sites must be redrilled, and the healing protocol followed again.

Patients hospitalized for surgery should inform the hospital that they are wearing dentures with intramucosal inserts. Assure the anesthesiologist that the denture is retentive and stable enough to permit intubation. The denture should not be removed. If it is, and receptor site closure occurs, the gingival receptor site drilling process is performed again.

Should a denture crack or fracture, it should remain seated in the mouth until it can be repaired at a subsequent visit. If a new denture must be fabricated, the most successful option is to place inserts at locations that correspond as closely as possible to the existing gingival receptor sites, redrill the gingival receptor sites as required for accuracy of the axis of insertion, and follow the healing cycle protocol.



FIG. 20-30 ■ Constricted gingival receptor sites.

VARIATIONS AND ALTERNATIVES

Free-End Saddle Maxillary Partial Dentures

Unilateral and bilateral maxillary free-end saddle removable denture cases require carefully designed attachment mechanisms. Gravity tends to drop the distal saddles. To compensate, some practitioners tightly attach the denture to the remaining anterior teeth. This in turn severely torques the teeth, resulting in a more guarded prognosis for the clasped teeth. Treatment with intramucosal inserts is very beneficial in such cases and is considered mainstream. The inserts keep the saddles in position, greatly stabilizing them. This enables the denture attachment to the teeth to be less rigid, reducing torque and enhancing the prognosis of the teeth. This course of action is highly recommended (Fig. 20-31).

Large Inserts

The dimensions of the mushroom head of large inserts are 25% greater than those of standard inserts. The stem and base are of the same dimensions. Therefore, the acrylic receptor site bur and acrylic receptor site testing instrument are the same, while the sizes of the tissue receptor site bur, tissue receptor site testing instrument, and acrylic trim bur are coordinated to the insert configuration. Treatment using large inserts is considered mainstream. In general, large inserts are used on the crest of the ridge posteriorly in cases with thicker overlying tissues. Because of their added retentiveness and ability to stabilize the denture, they are usually not used on the lingual inclines. Drilling gingival receptor sites for large inserts on the lingual inclines may cause tenderness, and the patient may experience unusual difficulty in removing and reseating the denture. When used on the ridge crest only, four or five are placed on each side from the cuspid area to the height of the tuberosity. Occasionally, large



FIG. 20-31 ■ Maxillary partial denture with intramucosal inserts.

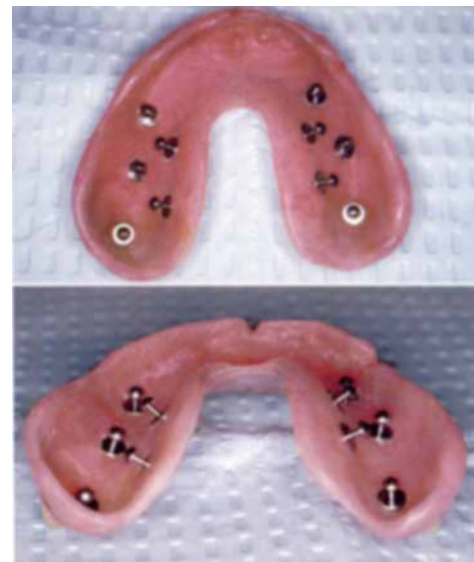


FIG. 20-32 ■ Large intramucosal insert denture.

inserts may be placed at the lingual incline when its angle to the ridge crest is sufficiently obtuse to allow removal and reseating of the denture with comfort (Fig. 20-32).

Marking Intramucosal Insert Sites Before Fastening Inserts

An interesting variation that works is the marking of gingival receptor sites intraorally, before fastening the inserts to the denture. To do this, first prepare all insert receptor sites in the denture base. Now there are two options. One is to insert the denture and send the patient home for up to a week to permit tissue to expand partway into the empty acrylic receptor sites. Clinically, one then observes slightly elevated round circles intraorally, in the exact spots where the inserts are planned. The second option is to immediately apply blue indelible marking pencil to the entire periphery of the acrylic receptor sites, section by section, and seat and reseat the denture to transfer the marking circle to the tissues. In either case, anesthetize and immediately

FIG. 20-33 ■ Intramucosal insert denture with metal base.

penetrate the center of the marking with the latch-type No. 3 bur in a slow-speed contra angle. Affix the inserts to the denture, and proceed with the protocol.

Healing Inserts

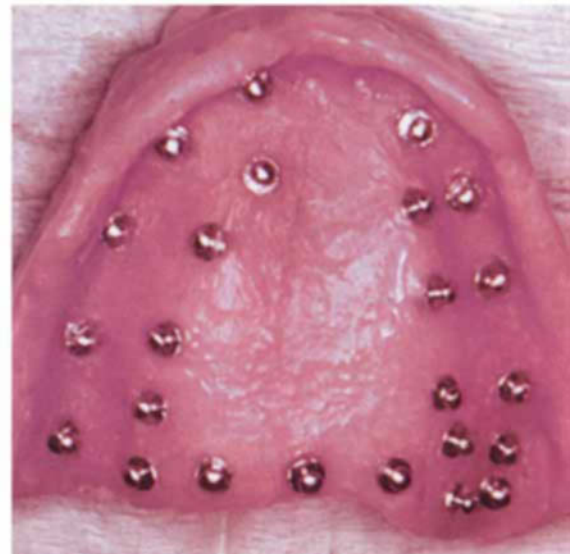
Healing inserts have a mushroom head and neck, and instead of a base, two flat, thin extensions that lie on the tissue surface. Using these inserts changes the treatment protocol. The healing inserts are placed into the prepared tissue receptor sites, and the denture, which is not attached to them, is placed over them to keep them seated during healing.⁸ Following healing, they are removed, final inserts are placed into the receptor sites and attached to the denture in the corresponding locations, and the denture is seated. The difficulties associated with fixing the final inserts to the denture at the precisely required locations after removal of the healing inserts may outweigh the benefits. Although not contraindicated, this variation may not be practical.

Metal Denture Bases

Some practitioners prefer metal denture bases to acrylic. When using a denture with a metal base, the positions of planned inserts are marked on the denture master model on which the metal base wax-up will be performed. The metal base is then cast, leaving ample-sized circular holes that are filled with acrylic to accommodate the fastening of the inserts to the denture base. The protocol proceeds conventionally (Fig. 20-33).

Inserts Placed Along the Posterior Palatal Border

Because of its rich blood supply, the proximity of nerves, and movement along the vibrating line at the juncture of the soft and hard palate, the posterior palatal border

**FIG. 20-34 ■** Excessive number of inserts and contraindicated posterior border locations.

is contraindicated for gingival receptor site preparation (Fig. 20-34).

Round or Ovoid Insert Heads

Early insert configurations had round or ovoid heads. Although they did enhance retention and stability, the mushroom-shaped head proved to be more effective. The mushroom-shaped head is now the configuration of choice.

Total Denture Palate Removal

In many cases, the additional retention and stability afforded by inserts enables the removal of palatal acrylic to

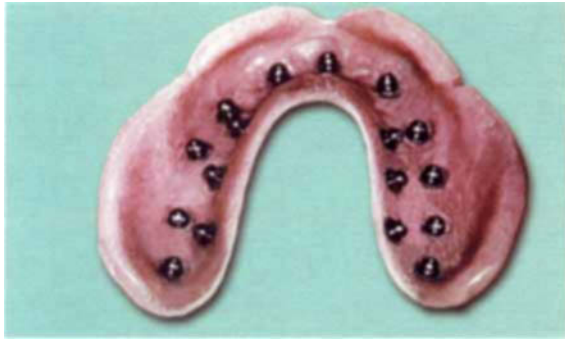


FIG. 20-35 ■ Insert denture with palate removed.



FIG. 20-36 ■ Intraoral view of insert denture with palate removed.

enhance tongue space and increase tactile and taste sensations, or to help prevent gagging (Figs. 20-35 and 20-36).

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21 Diagnosis, Formulation, and Presentation of Goal-Oriented Treatment Plans

DIAGNOSTIC CONSIDERATIONS

Physical Health

To be diagnosed as mainstream, a case must have appropriate available bone present for treatment with a professionally accepted modality. A limited number of implants are placed within a limited, well-defined area.

In addition to this vital clinical consideration, the patient's underlying general health must also be acceptable. One must determine whether a candidate for mainstream implant dentistry is "mainstream healthy." Equate the health requirements for mainstream implant dentistry with those for the removal of a molar. If, in accordance with one's office policies, one would remove a molar following consideration of peripheral health issues, then implant treatment can usually proceed. If adjunctive therapy of any kind would be required for molar removal, then the same therapy should be instituted for implant treatment. Information gleaned from a current health history form and discussion with the patient is invaluable in determining suitability for treatment. Ask whether the patient has been hospitalized during the past 5 years; whether there is anything about the patient's health that either the patient or his or her physician thinks is important for the implant practitioner to know; whether the patient has had urinalysis, an electrocardiogram (ECG), blood analysis or any other test, and/or a thorough physical examination in the past 18 months; whether the patient takes medication regularly; whether the patient has ever had a complication of excessive bleeding; and whether the patient has allergies. The patient's physician should be consulted to answer any questions. Explain to the physician what the implant treatment will be, why it is proposed, and what its benefits are. Most often, the physician is happy to know where to refer patients for similar treatment in the future.

Perfect health is not a must for diagnosing an implant case as mainstream. Identify any less-than-ideal conditions,

determine whether they can be treated, ensure that the patient is protected, and proceed. In the course of inquiring into health matters, cases that should not be considered mainstream become obvious. Keep in mind the axiom that patients with the most troubles need help the most. However, for one's first few mainstream cases, patients in excellent health are desirable. One should be able to focus on the implant treatment without worrying about peripheral health issues.

Mental Health

The same approach should be taken when evaluating a patient's mental fitness. Sometimes, in the course of interacting with a patient before treatment, a practitioner has qualms about proceeding. Doubts may arise about the patient's ability to understand the proposed treatment, or to cooperate. Sometimes, the practitioner may not be convinced that the patient really wants the treatment. In such cases, it is best to share one's concern with the patient to determine whether one's reservation is justified. Some patients are genuinely quiet people, and in fact fully understand and are enthusiastic about the treatment, whereas other patients are not ready to commit themselves emotionally or psychologically to treatment. The only way to differentiate between these types of patients is through conversation. Once "where the patient is coming from" is understood, the practitioner can proceed or not as he or she sees fit. Certain pharmaceuticals listed in a patient's medical history can also offer valuable information to the practitioner in evaluating mental fitness.

Some patients in consultation appear to be hostile. Hostility may be detected through comments, tone of voice, body language, or a combination of these cues. An excellent approach to hostile patients is to acknowledge their feelings

and take them in. Explain that you can see that they are upset, that you are sorry that this is the case, and that you do not want to contribute to whatever is upsetting them. The hostile patient should hear that the practitioner wants to be helpful. Often, this is enough to defuse the problem, and treatment can proceed. In other cases, the patient may need to share the source of his or her hostility before treatment. Some patients express their fear of dental treatment through hostility, whereas other patients may have unusual circumstances that make their cases non-mainstream. A hostile patient may best be handled by referral, or may need to receive the minimal possible salutary treatment to reduce the number of visits and treatment time.

The practitioner must be intuitive, caring, and straightforward. One should always ask, if treatment is successful clinically, whether the patient will be satisfied. Is it possible that the patient may not be satisfied regardless of the level of success of the treatment? If the answer may be yes, ask why, and talk to the patient about it.

Patient's Chief Complaint

Truly listening to patients in consultation before treatment is vital. Ask patients what results they seek from their dental treatment to learn how they feel about what they want, as well as their general feelings about treatment and about themselves. Identify what brought the patient to the office, write it down, and refer to it often as one plans, speaks with the patient, and treats the patient. In this way, the practitioner can make sure to give the patient what he or she really wants, what he or she asked for.

Patients are often thwarted in their efforts to communicate what they want by misconceptions, attempts at self-diagnosis, and the like.¹ Patients may say that they want a specific implant modality and a fixed bridge, but that does not really explain what they want. In truth, the patient may be trying to say that he or she no longer wants to wear his or her partial denture. Patients may say that they want "screws." However, if in consultation the practitioner determines that their case clearly calls for treatment with a subperiosteal implant, discussing the reasons for this with the patient may not be productive. It could be that the patient knows somebody who "got screws," and that this is the only treatment they are aware of that will obviate the need for their denture. In fact, the patient most likely has no preference regarding precisely what type of treatment he or she will undergo. The patient is chiefly interested in the result, not the method. Once the patient expresses that getting rid of his or her denture is desired, the practitioner then can agree with this treatment goal and can discuss the ways in which it can be achieved. With communication of this sort, patients tend to be more receptive to the practitioner's diagnostic recommendations.²

Patient's Dental IQ

Part of consultation should be an assessment of the patient's dental IQ. Such assessment is useful, because it

focuses responsibility where it belongs—with the practitioner. Dental IQ is a measure of one's ability to understand and desire the benefits of dental care, one's ability to want optimal treatment.³ If the patient's dental IQ is low, it is not their fault. Patients cannot know what the practitioner does not tell them. The practitioner is responsible for raising the patient's dental IQ. Essentially, this means helping the patient understand and desire the benefits of the treatment that they can be offered. How to accomplish this effectively is discussed later in this chapter.

Patient's Ability to Pay a Fair Fee

Whereas dental IQ relates to one's capacity to desire and appreciate optimal dental care, the ability to pay a fair fee often determines whether an optimal plan can be undertaken. When patients state that they cannot pay the fee, this may or may not be true. Sometimes, this means that the treatment offered is not worth the price to the patient. It is a question of value.⁴ In this case, it is possible that if the patient's dental IQ were higher, he or she would value the treatment more and therefore would be willing to afford the fee. In such cases, further patient education may be in order. Other patients who say they cannot pay the fee are actually testing to see whether the practitioner thinks the treatment is worth it, whether the practitioner believes in the treatment plan and the cost. They want to see if the practitioner will immediately alter the treatment plan, or immediately reduce the fee. Offering such a patient a compromised treatment plan at a reduced fee can lead to serious trouble. Differentiating such patients from patients who genuinely have a problem with payment is covered later in this chapter.

Some patients genuinely cannot afford optimal care. Offering the best care possible to such patients is also covered later in this chapter.

FORMULATION OF GOAL-ORIENTED TREATMENT PLANS

Optimal Treatment Plan

Taking advantage of the benefits of practicing implant dentistry changes everything related to treatment planning. Implant practitioners can create additional new abutment support for restorative dentistry in most patients who are partially or totally edentulous. In the past, a patient's treatment plan was formulated based on the availability of existing teeth for abutment support. Now, abutment support can be created where it is needed for optimal restoration.

The practitioner should explain this to the patient. The benefits and risks of treatment are other considerations of which the patient must be made aware, but are not necessarily the first order of business. Once patients are well informed, such that their dental IQ has been raised to the point at which they understand and want optimal treatment, the practitioner must discuss the specific treatment appropriate for that patient, along with its associated benefits and risks.

What is the optimal treatment plan? In answering this question, consider treatment planning in its broadest aspect. Because of implant dentistry, evaluating periodontal, endodontic, and prosthodontic conditions, nerve complications, and available natural tooth abutment support is no longer the essential first step. Whatever the preoperative presentation, whether totally or partially edentulous, and in the latter case whether the existing teeth can be saved or not, the benefits of implant dentistry are the same. The optimal treatment plan is to improve esthetics, conserve teeth that do not require removal, and provide nonremovable restorations when possible. Implant dentistry can make all this possible, regardless of the nature of the presented problem. This is precisely why implant dentistry revolutionizes dental diagnosis and treatment planning.

An example may help make this point. A patient presents with some missing teeth posteriorly, a few interdental, and has some correctable periodontal and endodontic complications. The esthetics are not acceptable, and the patient is aware of this. What is the goal of treatment for this patient? The patient wants to look good, to be able to speak without being self-conscious, to be free of impediments such as denture movement, salivary spray, and whistling sounds. The patient wants to be comfortable and free of pain and infection, and wants to be able to chew food and enjoy eating. These are the benefits of the optimal treatment plan. The patient undergoes treatment because of the anticipated benefits. Therefore, in this example, in its broadest aspect, the first step of optimal treatment planning is the determination that esthetics will be improved, all teeth whose treatment would result in a favorable prognosis will be retained, and all restorations, when possible, will be nonremovable. Following this essential first step, the practitioner writes down the exact treatment required, for each tooth, each area, with each dental discipline, to enable the optimal plan to be accomplished. The practitioner must determine if additional new abutment support is required to achieve the goal, and if so, where and to what extent. View the implants as additional new abutments that enable the execution of a goal-oriented treatment plan.

With these considerations, it becomes clear why the restorative practitioner should control the case and be the primary practitioner responsible to the patient when the team approach is used. If the restorative practitioner does not perform implant insertion, the patient may be referred to an insertion practitioner, who will confirm whether an appropriate modality can be used to provide sufficient support for the case at hand. The point of the implant treatment is to provide abutment support for use by the restorative practitioner. If appropriate or sufficient support cannot be provided, the restorative and insertion practitioners confer to reach an acceptable alternative plan.

In a simpler example, a patient's maxillary right central incisor has been removed. Healing is complete. The case is ideal for mainstream root form treatment. There is no need to reduce adjacent esthetic, healthy teeth. Although

this case is different in magnitude from the first example, it is not really different in spirit. In its broadest aspect, the first step of optimal treatment planning determines that esthetics will be improved, that any teeth that can be retained will not be removed, and that the restoration will be nonremovable if possible. This determined, the practitioner writes down the exact treatment required to enable this optimal plan to be accomplished.

The lesson is that the implant should be viewed as additional new abutment support for restorative dentistry, in every case. The practitioner creates this support. Discussing with the patient the details of how this will be done is not the first step. The first step is to determine the goal of treatment—to improve esthetics, conserve natural dentition, and provide fixed prostheses if possible. The details of how this will be accomplished—the exact treatment required—become germane when determining how to achieve this optimal goal.

Alternative Treatment Plans

Contingency Plans. It is wise to construct alternative treatment plans based on potential vagaries of treatment, such as whether periodontal therapy will succeed and offer a suitable prognosis for one or more strategically important teeth, or whether endodontic therapy on a tooth will be successful, such that the tooth need not be removed. Contingency treatment can be planned for these and similar considerations, with no change in the treatment goal. A dental implant can be inserted to provide equivalent abutment support in place of teeth that require removal. This ability not to have to compromise an optimal treatment plan because of a lack of adequate abutment support is a boon to dental treatment.

When General Health or Economic Concerns Exist. When general health concerns compromise the ability to execute the optimal treatment plan, the case is not mainstream by definition. Alternative plans that may not include implant treatment are required.

Economic concerns profoundly affect optimal treatment plans.⁵ When an economic problem is real, and not a manifestation of a low dental IQ, the practitioner must determine how to proceed. Many practitioners believe that in such cases, it is proper for all concerned to offer a special fee reduction. A fee reduction should only be offered to the right person with legitimate economic need, and for the good and proper reason of not wishing to compromise an optimal treatment plan. Even if one earns less, offering the optimal plan precludes having to worry about the increased upkeep and maintenance that could result from offering a compromised treatment plan. In some cases, the use of one modality or system instead of another may involve lower cost to the patient. This consideration can lower the fee without compromising the treatment goals. It is also possible to offer a payment schedule to patients who may not be able to pay a *fair fee all at once*, but appreciate the ability to pay the fee in its entirety over time, with no loss of dignity.

ESTABLISHING THE NEED AND CREATING THE DESIRE FOR OPTIMAL DENTAL CARE

One of the most important and satisfying aspects of practicing dentistry, with or without implant treatment, is the interpersonal relationships one forms with patients. It is one of the most complex, unpredictable, and interesting things about the profession. Because each patient is different, no one approach to patient interaction is always the best. The way to communicate with patients should be varied, molded, modified, and adjusted based on the personalities of the patient and the practitioner.

To best serve the patient, it is very important to differentiate clearly between establishing the desire for the goals of treatment, and the specific treatment plan that will accomplish these goals. Habit, personal training, and a plethora of insurance forms have made it difficult for many practitioners to give benefit-oriented case presentations instead of “nuts and bolts” procedure-related case presentations. Patients do not want injections, root canal treatment, drilling, periodontal therapy, caps, bonding, or implants. They will, however, accept these treatments to achieve their goal, which is to have the benefits of dental care.

One should address these benefits first, and then the treatment required to deliver them. If a patient presents with a darkly discolored restoration on the Class V labial/cervical area of an upper right central incisor, it may not be best to say, “You need a new filling.” It may be preferable to say, “We need to take care of that discoloration so you can smile, speak, and laugh without concern.” That establishes benefit, which is what the patient came for. Then, the treatment that will achieve these benefits is outlined.

Talking With Patients About Implant Dentistry

What Patients Really Want—The Physical and Emotional Benefits. Patients are willing to undergo dental treatment, but only to gain the benefits that such treatment can provide. Essentially, there are five benefits of dental treatment, listed in Box 21-1. These benefits greatly affect quality of life and should not be taken for granted.

Appearance. How one appears to others has much to do with how one appeals to others. First impressions are very important, and in large part are based on appearance. Compromised appearance is one of the most motivating factors that brings a patient to the office for treatment.

Speech. Also of great importance is the ability to speak without being aware of it. The etiology of self-consciousness when speaking may be poor esthetics, denture movement, missing teeth, salivary spray, odor, or improper occlusion. Regardless of the cause, being aware of speaking can change one’s personality, make one economize with words, retard spontaneity, and diminish one’s ability to really share who they are and what they think with others. Both in the workplace and privately, being able to communicate freely is vital.

BOX 21-1 ■ FIVE BENEFITS OF IMPLANT DENTISTRY TREATMENT

Improvement in appearance
Ability to speak without self-consciousness
Increased comfort
Freedom from infection
Improved ability to chew and enjoy eating

Comfort. Comfort—freedom from pain—is probably the benefit of dental treatment most often sought by patients. Most patients who arrive in pain leave with marked improvement. In addition to alleviating pain, the practitioner makes every effort to alleviate any discomfort associated with the treatment itself.

Freedom From Infection. Patients know that infection is not a good thing, and know that it should be eliminated. It causes discomfort and can cause odor and compromise esthetics. Even in the absence of these problems, patients understand that infection should be eliminated for its own sake, and often present for such treatment.

Ability to Chew and Enjoy Eating. Most people do not care enough about their health, and most patients do not associate compromised ability to chew food with compromised nutrition. The practitioner should talk about the importance of proper chewing of food. Well-chewed roughage, in later years, has actually been shown to prolong life. However, despite its importance, knowing the benefits of thorough chewing does not tend to motivate patients. Patients want to be able to chew without being self-conscious socially. They want to enjoy eating in social settings.

To Whom Are We Speaking—Satisfying Specific Needs

Basic Considerations. The five benefits of treatment—appearance, speech, comfort, freedom from infection, and ability to chew and enjoy eating—are not equally important to every patient. This section deals with how to determine which benefits are most important to any given patient, so the practitioner can help the patient want what he or she needs—optimal treatment, which in many cases can only be achieved with the help of dental implantology.

Feelings and logic are unrelated. People instantly know what they want—the feeling—and then rationalize the feeling so it seems to make sense. What follows are ideas that help to identify and understand the specific needs of different types of patients, to help motivate them to want the benefits of implant dentistry. Different patients tend to value the benefits of treatment differently. In helping the patient to appreciate and desire the benefits of treatment, the practitioner is promoting health and improving quality of life. Therefore, this is a very important aspect of what dental implant practitioners do.

BOX 21-2 ■ LIFE POSITIONS AND ASSOCIATED BENEFITS OF IMPLANT DENTISTRY

Romance: Improved appearance and ability to speak without self-consciousness

Recognition: Improved appearance and ability to speak without self-consciousness

Self-Preservation: Increased comfort, freedom from infection, and improved ability to chew

Money: All five benefits, if they represent a good return on patient's investment

Life Positions. People appear to pursue four significant goals, or “life positions”—romance, recognition, self-preservation, and money. Everyone is primarily motivated by one of these life positions, secondarily by another, and basically unconcerned with the remaining two. A person's life position is intimately related to what benefits of treatment they seek, as shown in Box 21-2.

ROMANCE. Most people have a life position of romance. They want to look good, be appealing, be with people, and have people want to be with them. They value love, warmth, and emotional appeal. People with this life position intrinsically understand that how they appear to others is inextricably linked with how they appeal to others. Therefore, people with a romance life position tend to value improved appearance and ability to speak most among the benefits of treatment.

RECOGNITION. Others pursue recognition. Often, these are the people who seek positions in governments, societies, and clubs. They take on difficult public tasks. They seem to do things simply for the benefit of others. For this person, a kind word, praise, a promotion, or a plaque is the tangible token of their reward. They feel great when they do good or make things better for others, and thereby gain in stature and position. For these people, although the reasons are different, the benefits of treatment that they want most are the same as people with a romance life position: improved appearance and ability to speak without self-consciousness.

SELF-PRESERVATION. People who have the self-preservation life position breathe deeply, know the nutritional value of the food they eat, and exercise for health—not for beauty or social contacts or the joy of competition for its own sake. They want to live long and feel well. How they look, being recognized, and how much money they are worth all are of little interest compared with staying alive and in good health for as long as possible. The most important benefits of treatment for such people are comfort, freedom from infection, and the ability to chew properly. The medical and dental professions encounter a comparatively greater percentage of people with this life position than do members of other professions, because people with a self-preservation life position take full advantage of the health industry.

MONEY. Fewer people have a life position of money than any other life position. For these people, money is mostly what they speak about. It is the money itself that they value—not the recognition it could bring, or its romantic possibilities, or even its capacity to prolong life. A person who has a life position of money is not necessarily a frugal or miserly person. Many of these people have little trouble spending money, but they must be convinced that they are making a good investment. Spending money must bring quantifiable dividends and have continuing returns. Thus, such people are interested in each of the five benefits of treatment, but they view these benefits—appearance, speech, comfort, freedom from infection, and ability to chew and enjoy eating—as investment dividends. Some people who have the money life position actually secretly enjoy paying a premium. These are the people who brag to their friends about how expensive their dentist is, and many of their friends with this life position become first-generation referrals.

Presenting Implant Dentistry Treatment Plans

Purpose of the Presentation—Take “Yes” for an Answer. The purpose of the case presentation is to help the patient to accept the optimal dental treatment plan. The purpose is not patient education for its own sake. Much patient education is performed, but it is a means to an end—helping the patient to understand and desire the benefits of the optimal treatment plan.

If a patient comes in for a consultation and tells you to be thorough, fix anything that is wrong, cause as little pain as possible, and finish treatment as quickly possible, the best possible response is, “OK, let's do it.” The patient understands, wants, and has requested optimal care. He or she is not asking for specific information regarding the treatment but is establishing goals. It may be emotionally counterproductive at this point to tell patients that before they agree to treatment, one must perform a thorough examination, gather information, take study models, and then discuss possible treatment plans with them. Of course, these things need to be done, and will be done in an orderly manner, but not necessarily before the patient agrees to wanting the benefits of dental treatment.

The patient must be given as much information as he or she can absorb at every juncture. This is part of the treatment. There is ample time with the patient to educate, inform, discuss, and obtain truly informed consent in advance of undertaking any procedure. However, it is important to understand that the purpose of the optimal mainstream dental treatment plan presentation is to help the patient understand and want what he or she needs: optimal care.

Benefit-Oriented, Goal-Oriented Presentation of the Treatment Plan. With a reasonable assessment of the life position of the patient, one should focus the discussion on the benefits that are the most important and appealing to that life position. Think of the presentation as a

conversation between the practitioner and the patient, not as a prepared lecture to be delivered to the patient. Give the patient what he or she needs to feel comfortable and to be fully informed. Try not to overdo or underdo it. Always think of the patient's comfort level. Some patients do not want to know all of the details. Tell them the basics of what they need to know and should know, including the benefits and risks. Answer questions fully. Many patients want to know everything. Such patients should be as fully informed as they wish to be, as long as they are not indulging in an exercise of increasing anxiety.

With any patient, it is important to establish rapport. One way to do this is by addressing the patient's life position. Talk about romance or recognition or self-preservation or money. Share your patient's feelings and points of view. This will help you to understand your patients, and enjoy them for who they are. The patient will also feel that he or she has finally found a practitioner "on the same wavelength." Establishing such relationships is one of the best ways to build your practice, because it increases patient referrals many times over.

Influence of Dental IQ and Ability to Pay on Fee Presentations. If the patient expresses resistance to undergoing treatment, it is usually at the time of the fee presentation. At this time, the practitioner's task is to determine whether the resistance is the result of a low dental IQ or a true inability to pay.

When a patient expresses resistance at the time of the fee presentation, a good approach is to ask whether he or she feels the treatment is not worth it or whether the problem is financial. This question must be asked without judgmental overtones and with no emotion except concern for the patient. Patients may reply that they have never heard of spending that much money for teeth. If so, the patient is saying that the treatment is not worth it. This may mean that the patient's dental IQ is still too low to appreciate the benefits of the proposed treatment, which certainly is worth a fair and reasonable fee. In this case, present the case again as if for the first time. Often, the benefits of treatment register with the patient on this subsequent presentation and he or she will agree to the fee without resentment. If the practitioner immediately compromises the treatment plan to lower the fee, a patient may agree but may also be resentful knowing he or she has actually cheated him- or herself by not getting the best care possible. In such cases, the patient's trust in the practitioner may also be compromised, either because the practitioner is willing to perform less-than-ideal treatment, or because the patient feels the practitioner tried to get away with performing more expensive treatment than necessary.

If presenting the benefits of treatment again does not motivate the patient to accept the fee, be prepared to let the patient seek treatment elsewhere. If a patient will not accept the fee, he or she usually asks if a compromised treatment can be offered. Explain that there is, but that performing less-than-ideal treatment when the patient can afford to pay a fair fee for ideal treatment would be wrong. The patient must care enough about his or her well-being

to take care of his or her problem with the most appropriate treatment. If the patient still does not agree to the treatment and fee, offer to refer him or her to another practitioner who may be able to communicate the benefits of ideal treatment more effectively, or who may feel that a different treatment plan represents the ideal. With this approach, patients come to understand that the practitioner really believes in the treatment and fee being offered, and this in itself usually motivates patients to accept the treatment plan without resentment.

Some patients have a high dental IQ and would like nothing more than to have the recommended treatment, but genuinely are unable to pay for it. For these patients only, one may wish to offer a payment plan. One may say to the patient, "Tell me how you would like to pay, and I'll try to say yes." The best approach in such cases is to prompt the patient to propose the terms of the plan, for two reasons. First, patients are more likely to honor a plan that they propose than a plan proposed by the practitioner. Second, if given the first opportunity to propose a plan, the patient usually volunteers to pay the fee more quickly than the practitioner would expect. The treatment plan may not have to be compromised, and neither does the fee.

Such cases may lend themselves to a divided treatment plan. It may be possible without compromise to first complete one quadrant, or one arch, and then treat the others months or years later. In cases of economic consideration, this reduces the immediate requirements, and enables one to proceed more or less optimally.

For some patients, payment plans do not help. They are simply not in a position to assume debt. For such a patient, for the right reasons, one can offer a reduced fee. If even the reduced fee is not acceptable, one can suggest alternative treatment plans, and tell the patient the truth about them. They are not optimal. The alternative plan seeks to preserve everything possible so that the optimal plan can be implemented in the future, if possible. Meanwhile, the patient will require more maintenance, diligent home care, and a commitment to more frequent recalling.

Other Types of Patients

Self-Fulfilling Prophecy. It has been said that there are two kinds of people in this world: those who think they can and those who think they cannot, and they are both right. Patients who say that they cannot wear a denture or undergo treatment are right. Suggest to this patient that it is a waste of time and money to initiate treatment unless he or she wants it. This is the truth. Treatment is difficult enough to render successfully when the patient is cooperating and enthusiastic. It is essential to successful treatment that the patient believe the treatment can succeed. Many patients, when confronted with the logical conclusion of their belief system, are truly upset with it, and undergo a radical change in attitude.

Inappropriate Request. Some patients have unrealistic expectations. A 55-year-old patient who wants the treatment to make him or her look 30 years old has made an inappropriate request. It may be possible that treatment will make the patient feel years younger, but actu-

ally looking half one's age is not possible. The practitioner who proceeds with treatment in this circumstance may have a very dissatisfied patient at its conclusion. The practitioner must alert the patient to what can realistically be expected. In a nonjudgmental tone, repeat the inappropriate request back to the patient verbatim. "Are you saying that you want this treatment to make you look like you're 30 years old, or you won't do it?" When the patient hears how that actually sounds, he or she will usually mitigate their request. On the other hand, if the answer is yes, then frank discussion and patient education is in order. The patient's expectations must be realistic before treatment is initiated.

Something for Nothing. For some patients, under certain circumstances, one may be tempted to offer a treatment for no fee. Doing so gives the practitioner a sense of satisfaction at having done a good deed. There is nothing wrong with doing this, but it is important to keep in mind that something that is given away for nothing is worth nothing. Make the patient aware of the benefit that is being offered, and what the service would usually cost. This establishes the value of the treatment, which in turn establishes appreciation.

PRECISE ANSWERS TO COMMON PATIENT QUESTIONS AND CONCERNS

The following common questions and appropriate answers have been adapted with permission from a patient registration booklet made available by the American Academy of Implant Dentistry (AAID) to dental implant practitioners. It contains patient records and forms of all types. To obtain a copy, contact the AAID directly. It is helpful to be prepared for the types of questions patients typically ask, and to review appropriate answers to these questions that the patient can readily understand.

Questions and Answers

What is an Implant? An implant is a synthetic replacement for a tooth root that allows a person to have nonremovable teeth or a more secure dental restoration. There are several types of dental implants. In consultation with the patient, the practitioner will recommend the type best suited for the patient's needs and general dental condition.

How is an Implant Used? Implants can be divided into two basic categories:

- Those that are inserted into the bone
- Those that are placed over the bone

In both instances, the implants are placed under the gum tissue and extend into the mouth.

What About My Teeth? Natural teeth in a healthy, well-maintained condition are the best thing one can possibly have. Nothing compares to them. Therefore, it is in the best interest of the patient's health and well-being to do everything possible to keep one's teeth in the best condition for the longest possible time. With good care on the

part of the patient, and with frequent dental check-ups, anyone can accomplish this goal.

How Can I Supplement My Teeth? When a tooth is lost, it is best to replace the tooth with a nonremovable restoration as promptly as possible. For the replacement of a single tooth, a nonremovable bridge is often very satisfactory. However, in replacing a number of missing teeth to restore chewing efficiency, a conventional fixed bridge does not increase the support that was present when the teeth were in the mouth. The artificial teeth of the bridge do not have roots. This is of little concern when dealing with a single tooth replacement. However, when two or three consecutive teeth are being replaced, or several teeth spread out intermittently throughout the entire arch, this loss of root support becomes important. New support needs to be added using implants, so the remaining teeth are not overloaded.

What About Partial Dentures? Partial dentures are either tooth-supported or tooth- and gum-supported. An entirely tooth-supported partial denture fills the space, but the supporting teeth are no stronger than they were before. With dentures that are partially gum supported, the gum tissue and bone structure beneath the denture shrink gradually, so the partial denture has to be replaced or relined periodically. If these areas are not relined, then space develops under the denture, and the remaining natural teeth must carry all of the chewing load. Either way, the teeth are overloaded. The overloaded teeth undergo accelerated bone loss and may eventually be lost. Also, a partial denture is removable. It is not permanently fastened in the mouth, as a nonremovable bridge is.

When I Lose a Tooth, What Happens to the Bone That Used to Support It? Nature provides bone to support teeth when they are present in the mouth. When the teeth are lost, the tooth-supporting bone is also lost gradually. Nature takes away what is not used. For example, a person who is bedridden for a long period loses muscle tone. The muscles become soft and wither away. In the mouth, the bone under the gums shrinks, and dentures get loose. Notice in the mouth of a person who has lost half of his or her teeth that the bone is still present around the teeth that remain. Where the teeth have been lost, bone and gum shrinkage is usually observed. Where implants have been placed and properly maintained, the bone is usually preserved, because the bone is being used in much the same way it was when the teeth were present.

How Well Will I Be Able to Chew? For comparison purposes, assume that a patient who has all of his or her teeth in a healthy, well-maintained, functional condition can chew at 100 percent efficiency. With every tooth lost, efficiency decreases. How much decrease there will be depends on whether or not the teeth are replaced, and in what manner. Ultimately, if no teeth remain and the patient is using properly fitted dentures on an adequate bony ridge, a chewing efficiency of 15 to 18 percent may be achieved. If the ridges are not adequate, the percentage decreases. With implants and nonremovable bridgework, a person may get back as much as 85 percent of the function

they had with their teeth, depending on the number of teeth present and their condition.

Are My Other Medical Concerns a Factor? Absolutely. All patients are provided with a health questionnaire. The patient should be healthy, without any hindrance to proper healing. When appropriate, the patient's medical practitioner is informed of the treatment provided by the dental practitioner, as well as the medications prescribed.

Will My Home Care Be Any Different? The dental care the patient provides at home must be first-rate. The teeth and implants must be kept cleaner than ever before. The patient must be able to use a toothbrush, dental floss, or other devices to keep plaque off the teeth and implants. If this is not done, the possibility increases that the implants will not succeed and will have to be removed. Furthermore, smoking and/or excessive alcohol consumption compromise excellent dental health.

Do I Need X-Rays? The patient must have a complete examination with x-rays, which may include panoramic or periapical radiographs. X-rays are also necessary for proper diagnosis and follow-up after treatment is complete.

Are There Any Special Considerations for My Opposing Teeth? The teeth or denture opposite the implanted area is a very important consideration in the success of implant treatment. It is better if there is no grinding of the teeth at night against the implant(s). Care must be taken not to overload the implant(s) by chewing on hard objects such as ice, which could even damage natural teeth. The patient should be conservative when engaging in physical activity that may damage the implant(s) or the underlying bone.

Will I Lose Any Feeling? Some cases have been reported in the dental literature in which nerve sensation has been lost following certain surgical procedures. This happens sometimes, but is usually temporary. Unfortunately, in some instances, complete nerve sensation has not returned even after many years. Such instances have also occurred following the removal of deeply impacted wisdom teeth. Loss of nerve sensation is usually temporary, and does not cause a drooping or sagging of the face. Motor nerves are never affected.

Is Implant Treatment Always Successful? No. Many variables must be considered when placing the implant(s). First, the patient must be healthy and able to heal normally. For example, if the patient has uncontrolled diabetes, inconsistent healing could complicate the procedure. If such a condition develops after the implant treatment has been performed, this too may complicate the future of the implant(s). Second, a proper diagnosis must be made, and the proper implant type and procedure must be selected for the individual patient. Third, the implant(s) must be treated properly by the patient and the practitioner. If either party is neglectful, complications could result. Fourth, if the patient is a heavy smoker or consumes alcoholic beverages excessively, the success of the implant(s) will be affected.

Do Implants Last a Lifetime? Very few things last a lifetime. Some implants have been in the mouth longer

than 30 years. However, the average life expectancy of an implant is shorter and is based on numerous variables such as the patient's health and proper maintenance. In the final analysis, whether the implant(s) last a lifetime depends on how the patient lives and how old he or she is when the implant(s) are placed. Every tooth a person possesses meets with one of two possible fates: it either lasts until the person's death, or it is removed at some point during the person's lifetime. The same fate applies to implants.

Is Age a Deterrent? No. Health is the determining factor. Many people in their seventies or eighties are better candidates for implant treatment than younger patients who have physical complications. Older individuals are more likely to need implants because they have lost more teeth and have lost more of their supporting ridges. This is akin to asking what is a good age for a hip replacement implant or a coronary bypass. Any procedure that can help preserve or improve quality of life is worth performing for a patient of any age.

Is It Possible That My Body Will Reject the Implants? Implants are made of biologically compatible materials that have undergone extensive testing over many years. Because these materials are usually metals, such as titanium or some surgical alloys, and have never been living tissue, there is no likelihood of their causing an antigen-antibody response that could lead to rejection similar to that which sometimes occurs with organ transplants.

Could Implants Possibly Cause Cancer? No instance has been reported in the dental or medical literature of dental implants causing cancer.

Are Dental Implants Inserted for Cosmetic Reasons? Not usually. The primary objective of dental implants is to give additional support to replacement teeth. Cosmetic enhancement is possible with the replacement teeth, however, and expectations should be fully discussed before treatment.

Are the Implants Guaranteed? There is no way to guarantee anything that is placed into the mouth and is under the control of the patient. Just as a physician cannot guarantee that a transplanted heart or kidney, or a coronary bypass will function for any specified period, a dental practitioner cannot guarantee the lifetime of an implant. The dental practitioner will strive to place the implant(s) properly, provide the patient with the information required to perform appropriate home care, and be available for regular follow-up appointments to evaluate dental health. The patient must also do everything possible to make the implant(s) succeed. Without complete patient cooperation, the implant(s) are more likely to fail. Also, the patient must return at regular intervals for examination and service. If not, difficulties may arise, possibly resulting in the loss of the implant(s). Because of the complex nature of implant dentistry, it is important that all postoperative examinations and/or treatments be handled by the same office. Referrals will be made only to appropriate practitioners with experience and training in implant dentistry.

Is It Expensive? Implant procedures, which vary in complexity and extent depending on the patient's dental condition and requirements, can involve a significant investment. Most patients after completion of treatment feel that it was worth the investment and that they would happily do it again.

Will Insurance Pay for Implants? Some dental procedures, implant surgeries, and portions of implant surgeries are covered by dental and medical insurance policies. Office personnel will assist you in obtaining these benefits.

Will There Be Discomfort? Just as with any surgery, there can be some discomfort. However, anesthetics virtually eliminate discomfort during the actual surgery. Post-operative discomfort is similar to that experienced after tooth removal. Patients are provided with medication to alleviate this discomfort.

How Much Time Does the Treatment Take? It depends on the patient's condition and needs, and the extent of the work involved. Individual operations may take from a half hour to several hours. There may be as little as one operation, or a series of operations and follow-up visits scheduled over a period of months to ensure proper healing, and fabrication of the tooth restoration.

How Long Will I Be Off Work? Most often, the patient can return to work normally as one would after a routine treatment visit. Other patients are more comfortable taking the day of surgery off from work, and possibly another day or two for recovery. Rarely is more recovery time required. The amount of time taken off from work is an individual decision. Some swelling, discomfort, and possibly some bruising can be expected and are not a cause for alarm. At no time is the patient without teeth in visible areas, although sometimes these teeth are only for social purposes, and should only be used for eating soft foods.

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22 Referring and Referrals

Most dental implant practitioners periodically choose to refer a patient, or have a patient referred to them for treatment. Some clinicians use the team approach in every case they treat, in which one member of the team acts as the insertion practitioner and the other acts as the restorative practitioner. Other clinicians prefer the solo approach, in which a single practitioner is responsible for everything from diagnosis and treatment planning through professional maintenance, including implant insertion and restoration. However, even solo practitioners are occasionally faced with a case that they cannot or choose not to treat themselves. For example, a solo practitioner who can comfortably treat mainstream endosteal cases may not wish to tackle an advanced subperiosteal case. In such cases, the normally solo practitioner may use the team approach, referring the patient to an insertion practitioner who has more experience with the modality or procedure called for, and then restoring the case and providing ongoing professional maintenance as the restorative practitioner.

With time, most dental implant practitioners are faced with the gratifying circumstance of having a case referred to them for treatment. In such cases, it is important to understand one's responsibilities to the referring practitioner. Whichever side of the referring/referral relationship one is on, it is vital that the relationship between the insertion and restorative practitioners be thoroughly understood by both parties, as well as by the patient.

The referral relationship, when conducted properly, is good for both practitioners involved, good for the profession in general insofar as it promotes harmony among experts and general practitioners, and most of all good for the patient. The patient of a team approach practitioner who does not have a good referral relationship in place may not receive optimal care. Therefore, it is in everybody's best interest for the referral relationship to be mutually respectful and beneficial. The corollary of this is that a substantial proportion of the legal difficulties that arise in the dental implant profession are the result of a referral relationship being handled poorly by one or both parties, or of a misunderstanding of the proper working relationship between the insertion and restorative practitioners in a team approach case.

Following is an overview of how the referring/referral relationship should work, and what the proper relationship between the insertion and restorative practitioners is

in team approach cases. This information is relevant to everybody who practices implant dentistry, and is important to the well-being of the patient.

RELATIONSHIP BETWEEN THE INSERTION AND RESTORATIVE PRACTITIONERS

In any referred case in which the referring practitioner continues to have some involvement with the implant treatment, there are two members of the team: the insertion practitioner and the restorative practitioner. The referring practitioner is most often the restorative practitioner, who has referred the case to the insertion practitioner. Cases in which the insertion practitioner refers to a restorative practitioner are less common.

It is important to understand that in any team approach case, the team members must reach common ground between the limits of insertion and the demands of restoration. From the restorative point of view, sometimes a case calls for a certain number of additional abutments, or a certain type of tissue integration either to support a prosthesis with natural co-abutments or to support a prosthesis independent of the adjacent teeth. However, from the insertion point of view, the ideal prosthodontic support requirements cannot always be met. If, for example, the restorative practitioner wishes to avoid preparing teeth, the use of osseointegrated implants is preferable in the presence of sufficient available bone. However, if in such a case there is insufficient available bone for mainstream treatment using osseointegrated implants, the insertion practitioner must inform the restorative practitioner that only an osteopreserved plate/blade form or a periosteally integrated subperiosteal implant is indicated, necessitating that the prosthesis be supported in conjunction with natural co-abutments. On the other hand, taken from an entirely insertion-related point of view, the use of a certain implant modality might be preferable given the anatomy and volume of available bone in the case at hand, but might not be the restorative practitioner's first choice. This means that the insertion and restorative practitioners should have clear lines of communication, must carefully consult with each other to reconcile the demands of restoration with the limits of insertion, and must agree on the course of action that will best serve the patient before treatment is begun.

Regardless of which practitioner makes the referral, it is essential in team approach cases that both the insertion and restorative practitioners be aware of the important principle that the restorative practitioner is in charge of the case. The reasons for this are numerous. The most important reason is related to one of the most fundamental concepts in implant dentistry. The point of dental implants is to provide additional abutment support for restorative dentistry. It is the restorative practitioner who determines that the patient requires such additional abutment support for the planned prosthesis. This ensures that implants are only used in cases in which they offer a tangible benefit.

The protocol for mainstream treatment of a case using an abutment-providing implant modality begins with the diagnosis that a patient can benefit from additional abutment support to enable the placement of a fixed prosthesis, a semi-fixed overdenture, or a single-tooth replacement, obviating the need for a removable total or partial denture. In the majority of such cases the patient originates with the restorative practitioner, so it is usually the restorative practitioner who makes this diagnosis. Then the restorative practitioner evaluates the prosthodontic demands of the case. Is it more advisable that the fixed prosthesis be supported by a combination of implant and natural co-abutments? If so, then the case calls for the use of an osteopreserved or periosteally integrated implant. Or, is it more advisable that the fixed bridge be supported entirely by implant abutments, for example in interdental cases in esthetic areas where one does not wish to reduce healthy and esthetic teeth? If so, then the case calls for the use of an osteointegrated implant. Having determined this, the restorative practitioner determines the number of abutments required. For use with natural co-abutments, one or two additional abutments are usually sufficient to place a fixed bridge. On the other hand, a fixed bridge or individual crowns supported entirely by osteointegrated implants may call for as many abutments as there are units in the prosthesis. Determining the number of abutments required is the job of the restorative practitioner, taking into consideration the needs and desires of the patient learned during consultation.

At this point, the restorative practitioner sends a written prescription informing the insertion practitioner that a patient is being referred, describing the need for additional abutments and whether or not natural co-abutments may be considered as additional support under the implant-supported bridge. This information assists the insertion practitioner in making an appropriate decision regarding the selection of the implant modality that, among other considerations, functions in the desired mode of tissue integration. It is now up to the insertion practitioner to examine the patient to evaluate whether these ideal prosthodontic requirements can be satisfied. It is hoped that the insertion practitioner determines that the available bone is adequate to satisfy the desires of the restorative practitioner, and this is very often the case. However, it also happens that the insertion practitioner determines that the

available bone is not appropriate for the use of an implant modality that functions with the type of tissue integration most appropriate to meet the ideal restorative requirements, or cannot accommodate the number of abutments desired. For example, in a case with severe alveolar ridge resorption, the insertion practitioner may inform the restorative practitioner that placement of osteointegrated implants will not be possible without extensive bone grafting, which is not mainstream. In such cases, the restorative practitioner may wish to or have to adjust the diagnosis and treatment plan to accommodate the limitations of the insertion possibilities.

Once the restorative treatment plan and the insertion possibilities are reconciled, treatment can proceed. In agreement with the restorative practitioner, the insertion practitioner may now insert the implants. The patient returns to the restorative practitioner for restoration after the period of healing appropriate for the type of tissue integration used. The appropriate protocols are rigorously followed by both the insertion and restorative practitioners.

The insertion practitioner cannot always accommodate the desires of the restorative practitioner. In the team approach, it is implicit that the restorative practitioner may have more experience and knowledge regarding implant restoration and the patient's needs and desires, and that the insertion practitioner may have more experience and knowledge regarding implant insertion. That is why the two practitioners are working together in the first place—each can apply his or her skills and talents for the good of the patient. It can also happen, however, that the insertion practitioner disagrees with the treatment or the diagnosis of the restorative practitioner, or will conceive of a treatment approach that he or she considers to be a superior option. If this is the case, the insertion practitioner should consider it appropriate and beneficial to share this opinion with the restorative practitioner, and the restorative practitioner should be appreciative of this second opinion. The point is to provide the best possible treatment for the patient, and both parties are concerned with achieving an optimal long-term result. It is very important, however, that the insertion practitioner first share this opinion directly with the restorative practitioner. If the insertion practitioner first expresses to the patient an opinion that the case has been misdiagnosed and that an alternative procedure should be undertaken, too often the result is patient panic, loss of confidence in one or both practitioners, and sometimes, unwarranted litigation. Instead, at the time of diagnosis and treatment planning, the insertion and restorative practitioners should consult with each other about the treatment possibilities in an atmosphere of mutual respect and constructive cooperation. Almost always, areas of disagreement can be resolved. Once the insertion and restorative practitioners resolve any such issues and mutually agree on a course of action, the patient is informed of any alternative courses of treatment that have been considered, and why they were rejected. Unresolved differences of opinion should be referred for another opinion, unless they directly bear on

the patient's expressed physical or financial condition, or time-related constraints.

In some cases, the restorative practitioner may diagnose a case for a fixed prosthesis, and send the patient to an insertion practitioner. The restorative practitioner expects that the insertion practitioner will determine whether he or she can use an implant modality that functions under the appropriate tissue integration for the requested independent support of a prosthesis or co-support with natural co-abutments, and whether there is sufficient available bone to accommodate the required abutment support requested. However, in some cases, the restorative practitioner may receive an unexpected appraisal such as, "I don't do that type of implant," or, "That modality doesn't work." The best course of action in such cases is to find an insertion practitioner who can fairly assess the suggested treatment plan for the case at hand. All of the mainstream modalities in this book have been proven safe and effective. An insertion practitioner who uses only one modality has a limited ability to serve the patient. Either the restorative practitioner can educate and motivate the insertion practitioner to broaden his or her scope of treatment, or refer the patient to an insertion practitioner who is more comfortable or familiar with the type of implant desirable for the case at hand.

REFERRAL RESOURCES

There are many reasons why a case may be referred out of the office. Some practitioners use the team approach as a matter of course. Many practitioners can perform implant insertion, but choose not to. It can also happen that a practitioner who generally employs the solo approach in mainstream cases encounters a patient whom the practitioner does not consider to be mainstream. Or, a solo practitioner may determine that the patient requires an implant modality with which he or she is not comfortable, and therefore wishes to refer the patient to a practitioner who has experience with this type of case.

In addition to the important consideration of when to refer—the natural rule of thumb is to do whatever one is capable of oneself—the question of to whom to refer is vital. Referral relationships are very important, and can be of great benefit to both parties. Referral relationships are built on trust and mutual respect, and can last for many years. The referring practitioner must be able to trust that the opinion received is sound, and that the practitioner to whom the case is referred makes every effort to support treatment decisions and uplift the referring practitioner's image in the patient's eyes.

The question is to whom to refer. Having an established referral relationship for other types of treatment with a practitioner who can also perform implant insertion is fortunate, because a relationship of trust is already established. If this practitioner's skill level in implant dentistry is sufficiently high, there is no reason not to extend the referral relationship to include implant insertion as well. If

no such established referral relationship already exists with a practitioner who can perform implant insertion, it is wise to confer with colleagues. One can be reasonably sure that an associate or peer has a good referral relationship with a proficient insertion practitioner.

If neither of these options is available, one must determine where to look for an appropriate practitioner for referrals. The following sections discuss the different types of implant insertion practitioners to whom one may refer. These groups are not presented in any hierarchical order—there are many excellent insertion practitioners in each group.

Periodontists

Periodontists have a long tradition of involvement in implant dentistry. Many of the discipline's most important innovators and researchers have been periodontists, and they maintain a well-deserved presence at the highest levels of the field, often chairing relevant departments, acting as luminaries, publishing important articles, and assuming positions of leadership in implant societies.

When considering whether to refer to a specific periodontist, it is wise to ask a few questions to verify that the periodontist is, in fact, proficient in implant insertion. Not all periodontists choose to offer implant insertion among the services they provide. Remember, although many periodontists may be considered experts in implant insertion, their education in periodontics does not automatically mean that they are. Periodontists who are experts in implant insertion have achieved this skill level through years of treating many cases. Ask the periodontist, or for that matter any practitioner to whom one may refer a case, how many cases he or she has performed, and for how many years. Confirm whether the periodontist is familiar with multiple implant modalities. Some are only familiar with the root form modality, and cannot be referred to for insertion of plate/blade form or subperiosteal implants. However, single-modality periodontists are certainly very valuable as team members in cases for which root form implants are indicated or desired.

Once an appropriate periodontist has been identified and the patient is referred for implant insertion, the periodontist most likely will want to recall the patient routinely to check on the health of the implant and surrounding tissues. After the case has been inserted and restored, the restorative practitioner and periodontist should stay in contact to arrange proper recalling, and to alert each other of any complications or deviations from the expected that may arise.

Oral and Maxillofacial Surgeons

Like periodontists, oral and maxillofacial surgeons have also made important contributions to the science and advancement of implant dentistry, and have a continuing and well-earned presence in the discipline. Much fine re-

search has been and continues to be conducted by oral and maxillofacial surgeons.

Again, as with periodontists, ask appropriate questions both to confirm adequate experience in implant dentistry in general, and if the case calls for it, to confirm familiarity with a specific modality.

When the referral relationship is established and the insertion has been performed by an oral and maxillofacial surgeon, it is common for the surgeon to recall the patient to check on the health of the implant, but not to perform routine follow-up procedures such as conservative gingival maintenance and prophylaxis. This is the domain of the restorative practitioner. If any deviation from the expected course or an unforeseen complication arises, the oral and maxillofacial surgeon is available for consultation or to examine the patient, if required.

American Board of Oral Implantology/ Implant Dentistry Diplomates

The credentialing board sponsored by the American Academy of Implant Dentistry (AAID) is the American Board of Oral Implantology/Implant Dentistry (ABOI/ID). Implant dentistry is not yet recognized as a specialty by the American Dental Association (ADA). In view of recent federal court decisions that uphold the validity of the ABOI/ID diplomate credential, as well as the AAID fellow and associate fellow credentials, the AAID is not expected to pursue specialty recognition for implant dentistry from the ADA in the near future. The ADA has established requirements that must be met to be designated as a sponsoring organization for a specialty application. Currently, the AAID, one of the oldest dental implant societies in the world, is the only society of implant dentistry that the ADA has recognized as meeting its requirements for a sponsoring organization for specialty.

Becoming a diplomate of the ABOI/ID represents reaching the highest level of credentialed achievement in implant dentistry. A substantial percentage of the most experienced luminaries in implant dentistry are periodontists and oral and maxillofacial surgeons. Currently, the respective board examinations for these disciplines do not establish expertise in implant dentistry per se. The only credentialing process that exclusively evaluates a practitioner's level of expertise and experience in implant dentistry is provided by the ABOI/ID.

There are more than 200 ABOI/ID diplomates, a mark of how demanding the requirements are. Educational requirements are stringent. All candidates must pass a written certification examination that is psychometrically validated, regularly updated, and administered under secure, fair, and unbiased conditions. The examination demonstrates in-depth knowledge of both the surgical and restorative aspects of multimodal implant dentistry and critical aftercare. In addition, the applicant must document, present, and defend an extensive portfolio of implant dentistry cases he or she has treated using more than one modality.

Other Validly Credentialed Expert Practitioners

Fellows of the AAID. In addition to sponsoring the ABOI/ID, the AAID administers a fellowship program. Fellows of the AAID must satisfy time and experience requirements, and undergo examinations that are in many aspects comparable to those of the ABOI/ID.

Other Credentialing Programs. Other excellent organizations, such as the Academy of Osseointegration (AO), an implant society that focuses its attention on osseointegration and the root form modality, are currently developing fellowship programs. Considering the fine stature and excellent reputation of the AO, their fellowship credential is expected to be meaningful.

When considering a candidate insertion practitioner who possesses an unfamiliar credential, do not hesitate to ask appropriate questions to determine how this credential was earned. Some credentialing bodies in implant dentistry have minimal time and experience requirements, and their testing methods are not rigorous. Not all credentials or certificates necessarily establish expertise.

Noncredentialed Expert Practitioners. Finally, it is worth noting that not every implant practitioner who has long experience and practices at an expert level has undergone a process that validates his or her expertise. In the final analysis, an expert is an expert, and when referring a case one should identify and work with an expert. If one has a relationship with an insertion practitioner who has decades of experience, has treated hundreds or even thousands of implant dentistry cases, and has been recommended by peers as being trustworthy and competent, the existence or lack of a verifying credential may not be crucial.

EDUCATIONAL ADVANCEMENT

Everybody starts as a beginner. One of the primary aims of this book is to assist students and practitioners of all types who wish to treat mainstream implant dentistry cases competently. For many practitioners, the ability to treat mainstream cases competently is all they desire. Most candidate patients for implant dentistry can be treated with mainstream procedures, so the ability to treat mainstream cases covers the majority of the need.

Many implant practitioners wish to expand their horizons and become experts. Remember, even the most revered experts in the field started as novices. They had to insert and/or restore their first implant, and build their experience slowly and surely over the course of many years, treating more advanced cases at appropriate intervals. There are several benefits to increasing one's level of expertise. First, one can treat more cases. Second, one receives more referrals as one's level of expertise increases. This in turn represents an increase both in prestige and income. Finally, advancing one's level of skill in anything simply for the joy of it, for its own sake, is rewarding.

23 Legal and Insurance Considerations

LEGAL CONSIDERATIONS

Taken as a whole, the United States is a litigious country. Television advertising by legal representatives urges patients to litigate on a fee-contingent basis. Certainly, every patient is within his or her rights to be treated properly following informed consent. However, the high volume of health-related legal cases, just or unjust, burdens a court's docket, causing delays in the administration of justice for all plaintiffs and defendants. The high volume of litigation has led to the practice of so-called defensive medicine and dentistry, which can be a good thing if not overdone. What is sad is the slow but continuing deterioration of the precious practitioner/patient relationship historically rooted in the dental profession.

What follows are some ideas and statements that may help clarify what the practitioner is faced with, in the hope that a better understanding of these considerations will serve not only the practitioner but also the patient. What follows is for information purposes only and does not constitute legal advice. It is important to understand that the laws related to these issues, while having much in common, vary state by state to the extent that in some states, portions of the basic tenets that follow may not apply.

Components of Accountability for Treatment Rendered

Negligence. Negligence is lack of ordinary care. It is the failure to use that degree of care that a reasonably prudent person would have used under the same circumstances. Negligence may arise from performing an act that a reasonably prudent person would not have performed under the same circumstances, or failing to perform an act that a reasonably prudent person would have performed under the same circumstances.

Proximate Cause. An act of omission is regarded as a cause of an injury if it was a substantial factor in bringing about the injury, that is, if it had such an effect in producing the injury that reasonable people would regard it as a cause of the injury.

Dental Malpractice. Failure of a case is not malpractice. Malpractice is professional negligence, and dental

malpractice is the negligence of a dental practitioner. Negligence is the failure to provide reasonable care under the circumstances, doing something that a reasonably prudent practitioner would not do under the circumstances, or failing to do something that a reasonably prudent practitioner would do under the circumstances. It is a deviation or departure from accepted practice.

A practitioner who renders dental service to a patient is obligated to have that reasonable degree of knowledge and ability that is expected of practitioners who provide dental services in the dental community in which the practitioner practices.¹

The law recognizes that practitioners' abilities differ, just as the abilities of people engaged in other activities differ. To practice dentistry a practitioner is not required to have the extraordinary knowledge and ability that belongs to a few practitioners of exceptional ability. However, every practitioner is required to keep reasonably informed of new developments in the field, and to practice dentistry in accordance with approved methods and means of treatment in general use. The standard of knowledge and ability to which the practitioner is held is measured by the degree of knowledge and ability of the average practitioner in good standing in the dental community in which the practitioner practices.

In performing a dental service, the practitioner is obligated to use his or her best judgment and to provide reasonable care. By undertaking to perform a dental service, a practitioner does not guarantee a good result. The fact that the patient experienced a bad result, by itself, does not make the practitioner liable. The practitioner is liable only if he or she was negligent, and if said negligence directly contributed to or caused the bad result. Whether the practitioner is negligent is decided based on the facts and conditions existing at the time of the claimed negligence.

A practitioner is not liable for an error in judgment if after careful examination he or she does what he or she decides is best, and if the judgment is one that a reasonably prudent practitioner could have made under the circumstances.

If the practitioner is negligent, that is, lacks the skill or knowledge required of him or her in providing a dental ser-

vice or fails to use reasonable care and judgment in providing the service, and such lack of skill or care or knowledge or the failure to use reasonable care or judgment is a substantial factor in causing harm to the patient, then the practitioner is responsible for the injury or harm caused.

Informed Consent. Before obtaining patient consent to perform a dental procedure, a practitioner must provide certain information about the proposed treatment, alternatives to that treatment, and reasonably foreseeable risks of that treatment.² The practitioner must explain, in words the patient can understand, all the facts that would be explained by a reasonable practitioner so that when the patient does, in fact, consent, that consent is given with an awareness of (1) the patient's physical condition, (2) the purposes and advantages of the procedure, (3) the reasonably foreseeable risks to the patient's health or life that the procedure may impose, (4) the risks involved to the patient if the procedure is not performed, and (5) the available alternatives and their associated risks and advantages.

However, a practitioner who has obtained informed consent is not released from accountability for future negligence that may occur.

Comparative Negligence. If a practitioner is found negligent and the negligence is found to have contributed to causing patient injury, it is next considered whether the patient was also negligent and whether that negligence contributed to causing the injury. The burden is on the practitioner to prove by evidence that a patient was negligent and that the negligence contributed to causing the injury.

If it is found that a patient was negligent and that the negligence contributed to causing the injury, the fault is apportioned between the patient and the practitioner. This is done by first weighing all the facts and circumstances, and then considering the total negligence, that is, the negligence of both the patient and the practitioner that contributed to causing the patient injury, and then determining what percentage of fault is chargeable to each.

Damages. Damage is determined based on evidence presented and the rules of law regarding whether the patient is entitled to recover from the practitioner. Only a jury can decide that a patient is entitled to compensation, and if so the measure of damages.

Expert Testimony. An expert is allowed to express an opinion on those matters about which he or she has special knowledge and training. Expert testimony is presented on the theory that someone who is experienced in the field can assist in understanding the evidence or in reaching an independent decision based on the facts.

In weighing the merits of a particular expert witness, one must consider the expert's qualifications, expressed opinions, basis of these opinions, and his or her reasons

for testifying, as well as all of the other considerations that ordinarily apply when deciding whether to believe what one hears. An expert's testimony should not be substituted for one's own reason, judgment, and common sense.

INSURANCE CONSIDERATIONS

The role of health insurance is increasing in importance for many patients.³ Generally, the insurance industry and health care provider organizations of all types grant coverage slowly for procedures related to developing specialties. Acceptance of implant dentistry by the profession and the public it serves has accelerated enormously since the early 1980s. This has further complicated an already complex situation, because of the various insurance plans offered as part of employee benefits, purchased privately, or provided by the government. Because benefits are defined separately for each general area, and within each area, and because an actuarial database for implant dentistry is not yet firmly established, industry and health provider organizations are only now in the early stages of providing adequate coverage.

How to Begin

Despite the difficulties just mentioned, substantial coverage for implant dentistry does exist. To take advantage of it, office staff should examine and understand each patient's dental insurance, and have at its command the applicable procedures and code numbers. In addition, procedure codes that apply to implant dentistry can be found in the patient's medical health insurance benefits. Each office should have knowledge of these medical procedure codes and an understanding of how the filing of medical claims differs in content and style from that of dental claim forms. Effort should always be extended to help patients realize the benefits to which they are entitled.

Procedure descriptions and their insurance code numbers, related to both dental and medical insurance coverage, are in a state of flux, and far too often are not evenhandedly applied. Offices should remain current and keep abreast of new developments to assist the patient at every juncture.

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Glossary

Abrasion 1. The wearing away of a tissue, substance, or structure through an intended or unintended mechanical process. 2. An area of body surface denuded of its external layer (e.g., skin, mucous membrane, enamel, or cementum) by some abnormal mechanical process.

Absorption 1. The uptake of substances into or through tissues (e.g., mucosa or skin). 2. The dissipation of force.

Abutment The portion of a tooth, implant, or implant component above the epithelium that serves to support and/or retain a prosthesis.

Acidic Corrosion The loss of elemental constituents to the adjacent environment as the result of the influence of a solution with a pH ≤ 7.0 .

Acrylic Receptor Site Bur A bur used to create receptor sites within the acrylic along the tissue surface of a maxillary denture for the affixation of intramucosal inserts.

Acrylic Trim Bur A trephine bur that removes excess cementing acrylic around the base of an intramucosal insert following fixation to the tissue surface of a maxillary denture.

Adhesion 1. The property of remaining in close proximity, as that resulting from the physical or chemical attraction of atoms of a substance or molecular attraction existing between the surfaces of bodies in contact. 2. The stable joining of parts to each other, which may occur abnormally. 3. A fibrous band or structure to which parts abnormally adhere.

Adsorption 1. The attachment of one substance to the surface of another. 2. The concentration of a gas or substance in solution in a liquid on a surface in contact with the gas or liquid, resulting in a relatively high concentration of the gas or solution at the surface. 3. The adhesion, in an extremely thin layer, of molecules to the surfaces of liquids or solids with which they are in contact.

Afunctional A condition of being in nonfunction. In implant dentistry, existing in a state such that the forces that affect healing are negligible, such as when an endosteal implant is submerged or semi-submerged in a protocol to achieve osteointegration. Compare *hypofunctional*, *hyperfunctional*.

Alkaline Phosphatase (ALP) Also *phosphomonoesterase*. An enzyme of the hydrolase class that catalyzes the cleavage of ortho-phosphate from orthophosphoric monoesters under alkaline conditions. Differing forms of the enzyme occur in normal and malignant tissues. The activity of such enzymes in serum is useful in the clinical diagnosis of many illnesses. Deficient bone enzyme activity, an autosomal recessive trait, causes hypophosphatasia.

Allogenic Graft Also *allograft*, *homograft*. Grafting material harvested from the same species as the recipient, but of a different genotype (e.g., a graft taken from one human and transplanted into another).

Allograft See *allogenic graft*.

Alloplast See *alloplastic graft*

Alloplastic Graft Also *alloplast*. Biotolerant grafting material that is synthetic (derived from a nonliving source).

Alveolar Process That portion of bone in either the maxilla or mandible that functions to surround and support the tooth roots or implants, if present. In the absence of either, known as the *residual alveolar process* or *residual ridge*. In the maxilla, called *processus alveolaris maxillae*; in the mandible, *pars alveolaris mandibulae*.

Amorphous 1. Having no definite form; shapeless. 2. Having random arrangement of atoms. 3. In pharmacy, not crystallized.

Analog, Implant Also *analogue*. 1. Also *implant try-in*. A replica or slightly undersized near-replica of the body of a specific implant configuration used for testing the size of a prepared implant osteotomy. 2. A replica of the abutment attachment/retention mechanism of an implant, for incorporation within a model used for prosthodontic restoration.

Analysis of Variance (ANOVA) A statistical procedure for comparison of the means of multiple random variables to assess the influence of certain factors on the means, or for the assessment of whether certain factors associated with a variable contribute to the variance.

Anastomosis A connection or confluence between vessels, cells, or connective tissue fibers.

Angiogenesis The formation of blood vessels.

Annealing Also *normalization*. Heating of a material, such as metal or glass, followed by controlled cooling to remove internal stresses and create a desired degree of strength, toughness, temper, or softness within a material.

Anterior Nasal Spine A median bony process, adjacent to the inferior margin of the anterior aperture of the nose, formed by a forward prolongation of the two maxillae. An important anatomic landmark in subperiosteal implantology.

Antigenicity Also *immunogenicity*. 1. The capability of inducing a specific immune reaction. 2. The degree to which a substance is able to stimulate an immune response.

Apatite 1. Calcium phosphate of the composition $\text{Ca}_5(\text{PO}_4)_3\text{OH}$; one of the mineral constituents of teeth and bones (with CaCO_3 or other substances). 2. Any of a group of minerals with the general formula $10\text{Ca}^{2+}: 6\text{PO}_4^{3-}: \text{X}^-$ where X is a monovalent anion such as a chloride, carbonate, fluoride, or hydroxyl ion; when it contains a hydroxyl ion the compound is hydroxyapatite (q.v.), an important inorganic constituent of teeth and bones.

Atrophy 1. A wasting away. 2. A diminution in the size of a cell, tissue, organ, or part.

Attached Gingiva Also *periodontum protectoris*. The portion of the gingiva that is firm, dense, stippled, resilient, and tightly bound to the underlying connective tissue, periosteum, bone, and the underlying cementum if present, thus being relatively immovable.

Attachment Mechanism Any component or device constituent with or placed upon an implant body to retain or attach a dental restoration.

Augmentation A procedure performed to create an increase in size or volume. In alveolar ridge augmentation, various grafting materials alone or in combination are used to increase the size of atrophic areas.

Autogenous Graft Also *autograft*, *autochthonous*, *autologous*. Grafting material harvested from one or more donor sites within the same individual.

Autograft See *autogenous graft*.

Autologous See *autogenous graft*.

Available Bone That portion of a healed partially or totally edentulous alveolar ridge that can be used for the insertion of an endosteal implant, or basal bone that can be used for the support of a subperiosteal implant.

Average Also *arithmetic mean*. The sum of a series of values divided by the number of values in the series. Compare *mean*, *median*, *mode*.

Barrier Membrane A device used to help confine a grafted area, help prevent overexpression and movement of the grafting material, and control the growth of undesirable tissue into the healing site.

Basal Bone 1. The osseous tissue of the mandible and maxilla underlying the alveolar processes. 2. The maxillary or mandibular bone against which a main bearing strut of a subperiosteal implant may be seated.

Base, Intramucosal Insert The portion of the intramucosal insert that seats within the acrylic receptor site on the denture's mucosal surface.

Baseline An observation or value that represents the normal background level, or an initial level, of a measurable quantity; used for comparison with values representing response to experimental intervention or an environmental stimulus, usually implying that the baseline and response values refer to the same individual or system.

Bioactive Having an effect on or eliciting a response from living tissue. Compare *bioinert*.

Biocompatibility The capacity to exist in harmony with the surrounding biologic environment; not having toxic or injurious effects on biologic functions, the host, or the device.

Bioelectric Current The electrical or electrochemical phenomenon that appears in living tissues, as may be generated by muscle, nerve tissue, and bone during function.

Bioelectric Signal A bioelectric potential or current that triggers a biologic response that may enhance or retard physiologic activity.

Biofunctionability The quality of being both compatible and functional with the biologic environment (e.g., in implant dentistry, with regard to force transfer within physiologic limits of health).

Bioinert Also *biotolerant*. Having minimal effect and eliciting a minimal response from living tissue. Compare *bioactive*.

Biomaterial Any substance other than a drug, synthetic or natural, that can be used as a system or part of a system that treats, augments, or replaces any tissue, organ, or function of the body.

Biomechanics 1. The application of mechanical laws to living structures, specifically the locomotor systems of the body. 2. The study of biology from the viewpoint of mechanical function. 3. An application of the principles of engineering design as implemented in living organisms. 4. In dentistry, the relationship between the biologic behavior of oral structures and the physical influence of function.

Body, Implant That portion of an endosteal implant that is placed within bone.

Bone Enhancement Any procedure that increases the volume of available bone, including grafting, nerve repositioning, ridge expansion, and distraction osteogenesis.

Bone Grafting The use of a tissue or material to repair a defect and/or add volume to existing bone.

Bone Morphogenic Proteins (BMPs) A group of noncollagenous factors, believed to be proteins, that mainly occur in bone and stimulate osteogenesis. Capable of inducing bone growth (osteoiduction) in nonosseous tissues.

Brittle 1. The property of being easily broken or shattered; fragile or crisp. 2. Prone to fracture or failure when the proportional limit of a material is exceeded. 3. Having insufficient plastic deformation in tension or compression before rupture.

Bullet-Shaped Crown A replacement tooth, usually posteriorly located in a fixed prosthesis because of esthetic considerations, tapered toward the gingiva from every aspect.

Cancellous Bone Also *spongiosa*. 1. The reticular, spongy, or latticelike portion of bone within cortical plates. 2. The spongy bone tissue located in the medulla, composed of a variable trabecular network containing interstitial tissue that may be hematopoietic and/or fatty.

Case Report A type of documentation in which diagnosis and treatment of a case are usually atypical, or in which a new procedure may be described.

Case Sequencing In implant dentistry, the protocol followed for a dental implant procedure, including timing of treatment as related to healing, tissue integration around the implant, and prosthodontic restoration.

CAT Acronym for *computerized axial tomography*. A radiographic procedure in which the emergent x-ray beam is measured and processed for display of the target region in any cross-section.

Cell Differentiation The process by which pluripotential cells differentiate into specialized cells such as osteoblasts, osteoclasts, fibroblasts, and erythroblasts.

Cell-Generated Signal A physical, mechanical, chemical, or electrical signal that originates from a cell to influence a physiologic process of tissue growth or repair.

Cement Retention The use of cement for the retention of an abutment or prosthesis. Compare *screw retention*.

Chelate To combine with a metallic atom or ion within complexes in which the metal is part of a ring. By extension, a chemical compound in which a metallic ion such as calcium is sequestered and firmly bound into a ring structure within the chelating molecule.

Clearance Angle The angle formed between the clearance face and the circumference of the bur.

Clearance Face The surface of the blade that follows behind the cutting edge as the bur rotates.

Coating A substance applied to all or a portion of the body of a dental implant with the goal of improving rate and quality of healing.

Cohesion 1. The act or state of sticking together tightly. 2. The force whereby similar atoms or molecules of matter adhere to one another; the attraction of aggregation. 3. Molecular attraction by which the particles of a body are united throughout their mass. Compare *adhesion*.

Coining The process of applying controlled pressure, stress, and heat in shaping a metal in a mold or die. In implant dentistry, the coining process permits formation of desired implant configurations and alteration of physical properties to enhance function.

Cold forging In implant dentistry, repetitive impact loading in the absence of applied heat.

Collagen The group of protein substances of the collagenous fibers of skin, tendon, bone, cartilage, and connective tissue composed of various molecules of tropocollagen.

Collar, Nylon The disposable sheath supplied with an intramucosal insert that protects against cement medium expressing into the retentive area under the head when the insert is affixed into its acrylic receptor site.

Complication An unfavorable condition, reversible or irreversible, that arises or is noticed at the time of treatment, healing, or function.

Component Also *element*. 1. In implant dentistry, a device that is attached to the body of an implant for healing or restoration. 2. One of the physically distinct parts of a modular device, or a single (monoblock) device.

Computer-Generated Bone Modeling The use of computerized scanning and milling technology to create a replicate model of bone intended to substitute for the stage one surgical process of direct bone impressing in the subperiosteal implant protocol.

Computerized Tomography (CT) See *CAT*.

Concentricity 1. The condition of a circle or circular object having the same center point as another circle or circular object. 2. In drilling, the maintenance of a constant center point of rotation.

Configuration In implant dentistry, a specific shape and size of implant. Compare *system*, *modality*.

Connecting Strut A strut on a subperiosteal implant that connects and unifies the buccal/labial and lingual main bearing struts.

Contact Inhibition The inhibition of cell division and cell motility in normal animal cells when in close contact with one another. In epithelial healing, the limiting of epithelial cellular migration as a result of direct contact with other normal epithelial or connective tissue cells.

Controlled A characteristic of a prospective clinical trial protocol whereby a control group, which does not undergo the experimental treatment or procedure, is followed to compare with and evaluate treatment of the experimental group.

Coronal 1. In implant dentistry, pertaining to the crestal portion of an implant body. 2. Pertaining to the crown of a tooth.

Corrosion The action, process, or effect of the loss of elemental constituents to the adjacent environment by means other than evaporation or friction.

Cortical Bone The dense, compact bone that surrounds the medullary cavity.

Counterbore The slight enlargement at the superior aspect of the osteotomy that allows the next gradual enlargement to take place.

Cover Screw A root form component that closes off the interior receptor area of an implant in the osseointegration healing protocol.

Cribriform Plate In dentistry, the alveolar socket proper formed by a dense aggregation of trabecular bone adjacent to a periodontal or peri-implant ligament.

Crosscut A bur with blades slotted perpendicular to its axis.

Crown-Root Ratio The ratio of the height of the crown above the ridge crest to the depth of the root within bone; useful as a prognostic tool.

Cushioning Effect The shock absorbing quality that directly results from the compression of the peri-implant ligament around an osteopreserved dental implant. Compare *hydraulic effect*.

Cutting Edge The functional point of intersection of the rake face and clearance face that is directly involved in the cutting action of the bur.

Cytotoxicity The capacity for an agent or metabolic product to exert a specific destructive action on certain cells, or the degree of such action.

Dehiscence 1. A splitting or peeling down along a natural line. 2. Separation of the layers of a surgical wound.

Delamination 1. In implant dentistry, the separation of a coating from its substrate. 2. Separation into layers.

Demineralized Freeze-Dried Bone Allograft (DFDBA) Freeze-dried bone allogenic grafting material that has undergone an additional step of demineralization (i.e., exposure in a .6N nitric acid for 6 to 16 hours). After washing and dehydration it may be either sterilized by ethylene oxide or irradiation to further reduce antigenicity.

Depth In implant dentistry, the dimension of an implant measured corono-apically, or of available bone measured apically from the ridge crest to the nearest limiting anatomic landmark. Compare *length*, *width*.

Depth Drill In implant dentistry, a bone drill designed to establish the angle and depth of an osteotomy.

Desiccation The act of drying.

Differential Diagnosis 1. In implant dentistry, the determination of the most appropriate implant modality for the treatment of a case in consideration of available bone and various clinical factors. 2. The determination of which one of two or more diseases or conditions a patient has, by systematically comparing and contrasting their clinical findings.

Diffusion Bonding Relative movement of atoms across an interface leading to unification of one part with another. In some situations, may be used to enhance the strength of porous surface layers intended for biologic ingrowth.

Distraction Osteogenesis The in vivo surgical sectioning of a selected area of bone, which through slow and controlled separation allows for incremental bone formation to increase volume and/or change configuration.

Ductility 1. The ability of a material to withstand permanent deformation under a tensile load without rupture; ability of a material to be plastically strained in tension. 2. The capacity of a material or substance to be drawn out, as into a wire.

Duty Cycle The relationship between magnitude of force absorption by alveolar bone and time, with or without an interposing, shock-absorbing ligament.

Dysfunction 1. Disturbance, impairment, or abnormality of the functioning of an organ. 2. The presence of functional disharmony between morphologic form (e.g., teeth, occlusion, bones, joints) and function (e.g., muscles, nerves) that results in pathologic changes in the tissues and/or produces a functional disturbance.

Edema The presence of abnormally large amounts of fluid in the intercellular tissue spaces of the body, of local or systemic origin, usually applied to demonstrable accumulation of excessive fluid in the subcutaneous tissues.

Edge Angle The angle formed between the clearance face and the rake face of a bur.

Elastic Deformation Deformation of a material or tissue such that it recovers to its original form from stretching, compression, or shear distortions.

Electric Discharge Method (EDM) Also *spark erosion*. 1. The process by which a metal can be precisely altered in form using electrical discharge current flow through conductive objects brought into contact with the metal surface. 2. A precision metal removal process using an accurately controlled electrical discharge to erode metal, as in the fabrication of coining dies, usually performed in a liquid dielectric medium.

Elongation 1. Deformation as a result of tensile force application. 2. The degree to which a material will stretch before breaking.

Embryonic Cell A cell of embryonic origin, or from a cell line of embryonic origin (e.g., stem cells and mesenchymal cells). Pluripotential cells and progenitor cells can be of embryonic origin.

Emergence Profile The contours of a tooth or restoration, such as a crown on a natural tooth or dental implant abutment, and its relationship to adjacent tissues at the pergingival site.

Endodontic Stabilizer Implant An endosteal implant that passes within, seals, and extends through the apex of a compromised tooth into the available bone beyond to have the biomechanical effect of lengthening the tooth root for the stabilization and improvement of the crown-root ratio to enhance prognosis.

Endogenous 1. Growing from within. 2. Developing or originating within the organism, or arising from causes within the organism.

Endosteal 1. Occurring or located within bone. 2. Pertaining to the endosteum.

Endothelium The layer of epithelial cells that lines the cavities of the heart and of the blood and lymph vessels, and the serous cavities of the body, originating from the mesoderm.

Engineering In implant dentistry, the planning or function of abutment support in terms of strength, number, and positioning, influencing long-term function of a prosthesis within physiologic limits of health.

Enzyme A protein molecule that catalyzes chemical reactions without itself being destroyed or altered. Symbol E.

Epithelial Attachment Also *junctional epithelium*. A single or multilayer of nonkeratinizing cells comprising a band or wedge of epithelium, the external surface of which adheres to the internal surface of the lamina propria of the free gingiva, or a crown, forming a peripheral cuff that seals the periodontal tissue and protects it from foreign material in the oral cavity.

Epithelial Migration See *contact inhibition*.

Epithelium 1. The covering of internal and external surfaces of the body, including the lining of vessels and other small cavities, consisting of cells joined by small amounts of cementing substances. 2. In dentistry, the mucosal tissue lining intraoral surfaces. It extends into the gingival crevice and adheres to the tooth at the base of the crevice.

Erythroblast Any type of nucleated erythrocyte, commonly designating a precursor cell from which an erythrocyte develops.

Etching 1. The act or process of selective dissolution. 2. In dentistry, the selective dissolution of the surface of tooth enamel, dentin, porcelain, or a dental implant through the use of acids or other agents (etchants) to create a retentive surface.

Fatigue Strength The point at which a material will fracture in response to cyclical loads at magnitudes below the yield strength.

Feet On some plate/blade form implants, the apical portion at the base of the implant body that extends between vents.

Fibroblast A flat, elongated cell associated with the formation of the fibro-collagenous network of the body, including tendons, aponeuroses, and supporting and binding tissues.

Fibronectin An adhesive glycoprotein important in connective tissue, where it cross-links to collagen and is involved in aggregation of platelets.

Fibro-Osseointegration A term previously used to describe any nonosteointegrated type of tissue integration, covering both osteopreservation (q.v.) and periosteal integration (q.v.).

Finite Element Analysis In implant dentistry, a computer-assisted method in which a device and the bone or tissues with which it will be associated are theoretically modeled using geometric shapes (elements) in which each corner (node) of the shape can be analyzed for direction, magnitude, duration, and rate of force transfer along each axis.

Fixture A type of root form implant.

Force Component A specific direction of applied force.

Force Distribution Bar On some plate/blade form implants, a bar, circular in cross section, extending along the implant base for more favorable distribution of forces.

Freeze-Dried Bone Allograft (FDBA) Bone harvested from donor cadavers, washed, ground to a selected particle size, immersed in ethanol, frozen in nitrogen, freeze-dried and ground to smaller particles ranging from 250 to 750 μm .

Frictional Fit In implant dentistry, the state of retention of a plate/blade form or root form implant at the time of insertion that results from slight compression of the osteotomy walls by the implant body.

Genial Tubercles Mental spines; rounded elevations clustered around the midline on the lingual surface of the lower portion of the mandibular symphysis.

Gingival Flap Plastic Surgery In implant dentistry, the surgical procedure by which gingival flaps are reduced in thickness, trimmed, or otherwise recontoured in preparation for suturing to promote long-term health and improve prosthodontic retention and esthetics.

Gingival Index A scale in which a score is assigned based on observed gingival conditions around teeth or implants, particularly pocket depth, mobility, and propensity of fluid transfer inducing bleeding.

Gingival Receptor Site A site in attached gingival tissue of the maxillary crest or lingual incline prepared to receive an intra-mucosal insert.

Glycoprotein A conjugated protein present in ground substance containing one or more covalently linked carbohydrate residues. Although technically describing conjugates in which the carbohydrate is less than 4% by weight, the term is often used generically to include the mucoproteins and proteoglycans.

Grafting Material A substance, natural or synthetic, used to repair a tissue defect or deficiency.

Grain Structure The orientation of grains or crystals within a metal or other substance.

Ground Substance The amorphous gel-like material in which connective tissue cells and fibers are embedded.

Ground Substance-Generated Signal A chemical or bioelectric signal that originates from ground substance to influence a physiologic process of tissue growth or repair.

Hammock Ligament The slinglike meshwork of peri-implant collagenous fibers contiguous with the outer layer of the periosteum that sheathes a subperiosteal implant in the periosteal mode of tissue integration.

Harvesting The collection of bone from a donor site (e.g., in the process of osteotomy preparation) for use as an autogenous grafting material.

Head, Intramucosal Insert The retentive portion of the intramucosal insert that seats within the gingival receptor site.

Healing Collar 1. A component of an endosteal implant attached to the implant body that is flush with or protrudes approximately 1 mm above the gingiva to promote osteointegration in the semi-submerged healing protocol. 2. In some root form systems, synonymous with cover screw (q.v.).

Hematopoietic 1. Pertaining to or affecting the formation of blood cells. 2. An agent that promotes the formation of blood cells.

Hemidesmosome A structure similar to a desmosome but representing only half of it, found on the basal surface of some epithelial cells, forming the site of attachment between the basal surface of the cell and the basement membrane in the area of the sulcular attached gingiva around a tooth or implant.

Heterograft See *Xenogenic graft*.

Heterologous Graft See *Xenogenic graft*.

Hex, External A hexagonal portion of the body of an implant extending from its coronal aspect that mitigates rotational tendencies of attached components.

Hex, Internal A hexagonal portion of the body of an implant within its coronal aspect that mitigates rotational tendencies of attached components.

Homograft See *allogenic graft*.

Host Site In bone augmentation, the site into or onto which a graft or transplant material is placed.

Hydraulic Effect In implant dentistry, the shock-absorbing quality that results from the movement of fluid within interstitial spaces or anastomosing blood or lymph vessels of the tissues around a functioning osteopreserved or periosteal integrated implant.

Hydroxylapatite (HA) Ceramic An inorganic compound, $(\text{Ca}_3(\text{PO}_4)_2)_3 \cdot \text{Ca}(\text{OH})_2$, found in the matrix of bone and teeth, which gives rigidity to these structures. Compounds that have this approximate chemical formula are synthesized for use as calcium supplements, prosthetic aids, and a dense, nonresorbable, biocompatible ceramic used for dental implants and residual ridge augmentation.

Hyperfunction A state of being subjected to force in excess of the physiologic limits of health.

Hyperplasia The abnormal increase in the number of normal cells in normal arrangement in a tissue. Compare *hypertrophy*.

Hypertrophy The enlargement or overgrowth of an organ or tissue beyond that considered normal as a result of an increase in size of its constituent cells in the absence of tumor formation. Compare *hyperplasia*.

Hypofunction A condition of being subjected to force that is below the minimum physiologic limits for health.

Hypoplasia Defective or incomplete development of an organ or tissue.

Iatrogenic Resulting from the activity of the clinician; applied to complications induced in the patient by the clinician. Compare *idiopathic*.

Idiopathic Self-originated; applied to pathology of unknown causation. Compare *iatrogenic*.

Immunoglobulin Any of the structurally related glycoproteins that function as antibodies, resulting in viral neutralization or the inability of some bacteria to invade mucosal surfaces coated by the antibody. Secretory immunoglobulin A is the predominant immunoglobulin in secretions, including mucus and saliva.

Implant, Dental A prosthetic device of biocompatible material(s) placed within or against the mandibular or maxillary bone.

Implant Dentistry Dental treatment associated with the use of dental implants.

Independent The condition of a study or clinical trial being conducted by investigators who are disinterested in the potential success or failure of the experimental protocol.

Inferior Alveolar Canal A canal that traverses the ramus and body of the mandible between the mandibular and mental foramina, transmitting the inferior alveolar vessels and nerve.

Informed Consent Permission to administer or perform a treatment granted by a patient with full knowledge of its benefits and risks, as well as alternative treatments and their associated benefits and risks.

Insertion Practitioner In the team approach, the practitioner who is responsible for implant placement.

Integration The condition of a healed dental implant existing in biologic and functional harmony with its environment.

Interface, Implant The surface of an endosteal or subperiosteal implant in contact with its investing tissues.

Interface, Tissue The border of the tissues in contact with the dental implant.

Internal receptor The space within the coronal portion of a conventional root form implant body into which components are fastened.

Intramucosal Inserts Also *submucosal inserts*, "buttons." Mushroom-shaped devices fastened to the tissue surface of a maxillary removable partial or total denture that fit within prepared gingival receptor sites for increased retention and stability of the denture.

Intraosteal Inserts Mushroom- or tear drop-shaped devices fastened to the tissue surface of a denture that fit within osteotomies lined with epithelium, for use in the mandible or in cases of unusually thin maxillary gingiva.

In vitro In an artificial environment; observable in a test tube; within a glass.

In vivo Within the living body.

Isograft Also *isogeneic graft*, *syngraft*. A graft from one genetically identical individual to another, as in monozygotic twins.

Keratinization The process of maturation of keratinocytes. The formation of a protein layer (keratin) on the surface of some epithelia.

Laminin An adhesive glycoprotein component of the basement membrane that binds to heparan sulfate, type IV collagen, and specific cell-surface receptors and is involved in the attachment of epithelial cells to underlying connective tissue.

Length In implant dentistry, the mesio-distal dimension of an implant or of available bone measured between anatomic landmarks. For root form implants, length is the implant diameter. Compare *depth*, *width*.

Ligament 1. A band of collagenous tissue that connects bone to bone or cartilage, serving to support and strengthen joints and limit range of motion. 2. In the osteopreservation mode of tissue integration, a band of tissue originating from trabeculae of the cribriform plate, passing against and around the adjacent implant, anastomosing, and reinserting into opposing trabeculae. Serves as implant support and reduces stress transfer to adjacent bone. 3. A double layer of peritoneum extending from one visceral organ to another.

Longitudinal The characteristic of a study or clinical trial in which measurements from each subject within each group are considered at every measurement interval.

Main Bearing Struts The struts of a subperiosteal implant designed to transfer functional load to basal bone.

Mainstream Implant Dentistry The use of any professionally accepted modality in uncomplicated, predictable treatment applicable to most implant candidates.

Major Diameter The diameter of a threaded implant, such as a root form or endodontic stabilizer, measured from apex of the thread to apex of the thread. Compare *minor diameter*.

Marking Teat The raised point at the apex of the head of an intramucosal insert that marks the gingiva to indicate the location of its planned gingival receptor site.

Matrix 1. A mold or impression in which something is formed. 2. The intracellular substance of a tissue or the tissue from which a structure develops. 3. The groundwork on which anything is cast, or that basic material from which a thing develops.

Maxillary Sinus The anatomic space located superior to the posterior maxillary alveolus.

Mean A number that in some sense represents the central value of a set of numbers. Compare *average*, *median*, *mode*.

Median The midpoint value of a series of numeric values.

Mental Foramen An opening on the lateral part of the body of the mandible, usually between and inferior to the apices of the bicuspid teeth, for passage of the mental nerve and vessels.

Mental Protuberance A more or less distinct and triangular prominence on the anterior inferior surface of the body of the mandible, on or near the median line.

Mesenchymal Cell A pluripotential cell of the meshwork of embryonic connective tissue in the mesoderm from which the connective tissues of the body are formed, and also the blood and lymphatic vessels.

Metric Scale A scale used to classify data according to the system of measurement based on the meter (length), the gram (weight), and the liter (volume).

Microcorrosion Cast A histologic specimen resulting from the in vivo injection of plastic into the blood vessels, which are then digested in vitro along with the other soft tissues, leaving only the bone and plastic to reveal the area's vascularization.

Micromovement In implant dentistry, the "give" or resilience of an implant in response to limited function during healing, which contributes to the formation of a peri-implant ligament in the osteopreservation form of tissue integration.

Micron Also *micrometer*. One millionth of a meter.

Microsphere The minute, round structural element used in the process of surface treatment of certain implant interfaces, often for the formation of porosities to increase surface area and retention.

Microvasculature The portion of the vasculature of the body comprising the finer vessels, sometimes described as including all vessels with an internal diameter of 100 microns or less.

Millimeter Measuring Rod An instrument with clear demarcations of each millimeter used in the endodontic stabilizer insertion protocol to promote accurate radiographic assessment of the depth of the treated tooth's apex and the osteotomy beyond.

Minor Diameter The diameter of a threaded endosteal implant, such as a root form or endodontic stabilizer, measured from the base of the thread to the base of the thread (shaft only). Compare *major diameter*.

Mobility 1. Capability of movement, of being moved. 2. In dentistry, the measured range or absence of movement of a tooth or healed endosteal implant.

Modality A broad, generic category of dental implants distinct from other modalities with regard to its basic shape, insertion protocol, case sequencing, intended mode of tissue integration, and restorative requirements.

Mode 1. A type of tissue integration. 2. The value repeated most often in a series of values.

Mode of Tissue Integration The manner in which a successful, functional dental implant is incorporated within its environment. The modes of dental implant tissue integration are osteointegration (q.v.), osteopreservation (q.v.), and periosteal integration (q.v.).

Modulus of Elasticity The coefficient found by dividing the unit stress, at any point up to the proportional limit, by its corresponding unit of strain; a ratio of stress to strain. As the modulus of elasticity rises, the material (e.g., metal or bone) becomes more rigid.

Mucopolysaccharide 1. Glycosaminoglycan; an oral defense mechanism against infection of the pergingival site around a tooth or implant. 2. Less frequently, any polysaccharide with a high hexosamine content, including the glycosaminoglycans, which are acidic, as well as neutral polysaccharides such as chitin.

Multimodal Implant Dentistry The practice of implant dentistry using differential diagnosis to determine the most appropriate professionally accepted modality for each case, thereby expanding the scope of treatment.

Neck 1. In implant dentistry, the portion of a plate/blade form implant that connects the body to the attachment/retention mechanism. 2. The portion of an intramucosal insert that connects the head to the base. 3. In some root form systems, the polished portion at the most coronal aspect of the implant.

Necrosis The sum of the morphologic changes indicative of localized cell death and caused by the progressive degradative action of enzymes; it may affect groups of cells or part of a structure or an organ.

Nerve Repositioning In implant dentistry, the surgical procedure whereby the course of a nerve is redirected to increase the volume of available bone for implantation.

Newton The unit of force that, when applied in a vacuum to a body having a mass of 1 kg, accelerates it at the rate of 1 m²/sec.

Nonresorbable The property exhibited by substances that demonstrate relatively limited in vivo degradation. Compare *resorbable*.

Nutrient A substance necessary for growth, normal functioning, and maintaining life, such as proteins, minerals, carbohydrates, fat, and vitamins.

One-Stage Implant An implant equipped with its abutment/attachment component at the time of insertion, precluding the need for second-stage treatment to expose and/or attach the abutment/attachment component.

Onlay Graft Augmentation by placing autogenous bone and/or appropriate substitutes on or over bone to increase depth, length, and/or width.

Ordinal Scale A scale used to classify data into qualitative ordered categories; the values have a distinct order but are not separated by numeric distances. Compare *metric scale*.

Ossification 1. The natural process of bone formation; the hardening into bony substance. 2. A mass of ossified tissue.

Osteoblast A cell that is associated with the mineralization of the bone matrix.

Osteoclast A large multinuclear cell associated with the absorption and removal of bone.

Osteoconduction The process by which an inorganic material provides a bioinert scaffolding along which bone growth can occur.

Osteogenic Promoting the development and formation of bone, exclusively resulting from the action of osteoblasts.

Osteoinduction The induction of bone formation in the absence of a bony host site; for example, certain bone morphogenic proteins (BMPs) can cause pluripotent cells circulating in the blood supply to differentiate into osteoblasts to form bone in nonosseous tissues.

Osteointegration The mode of tissue integration around a healed functioning endosteal implant in which the prime load-bearing tissue at the interface is bone.

Osteopreservation The mode of tissue integration around a healed functioning endosteal dental implant in which the prime load-bearing tissue at the interface is a peri-implant ligament composed of osteostimulatory collagen fibers that diminish the functional force passed to the surrounding bone.

Osteostimulatory Acting to stimulate, enhance, or accelerate the formation of bone in and around a host site, augmentation material, or endosteal implant.

Osteotome A chisel used to cut or expand bone.

Osteotomy In implant dentistry, a site prepared in bone for the placement of an endosteal implant.

Overdenture Abutment Analogue A replica of an overdenture attachment/retention component for incorporation with a laboratory model for prosthesis fabrication.

Overlap Case A case in which the available bone is suitable for the use of more than one dental implant modality.

Overengineering Excessive abutment support in endosteal implant dentistry. Overengineering can result in understimulation of the tissues supporting the implants and consequent bone loss resulting from hypofunction. Compare *underengineering*.

P-15 Residue Peptide A synthetic clone of the 15 amino acid sequence of type 1 collagen that is uniquely involved in the binding of cells, particularly fibroblasts and osteoblasts; essentially a very small synthetic fragment of the $\alpha 1$ chain of type 1 collagen.

Paralleling Pin In endosteal dental implantology, a device inserted into initial entry pathways to guide the practitioner in the establishment of parallelism in the preparation of serial osteotomies.

Particulate Composed of small particles or parts.

Passivation A process whereby metals and alloys are made more resistant to corrosion through treatment to produce a thin and stable oxide layer on the external surfaces.

Pergingival Struts On a subperiosteal implant, struts that protrude through the gingiva to provide abutments or attachment/retention mechanisms for restorative dentistry.

Periosteal Integration The mode of tissue integration around a healed functioning subperiosteal implant in which the prime load-bearing tissue at the interface is a sheath of dense collagenous connective tissue contiguous with the outer layer of the periosteum, which diminishes the functional force passed to the underlying cortical surfaces of basal and other supporting bone.

Periosteum A specialized connective tissue covering all bones of the body, except at articular surfaces, that possesses bone-forming potentialities; in adults, it consists of two layers often not sharply defined, the external layer being a network of dense connective tissue containing blood vessels, and the deep layer composed of more loosely arranged collagenous bundles with spindle-shaped connective tissue cells and a network of thin elastic fibers.

Peripheral Speed The speed at which any point on the circumference of a bur or drill travels; a function of rotational speed and bur or drill diameter.

Phagocytic Cell Any cell, such as a macrophage, capable of ingesting particulate matter, microorganisms, and particulate antigens coated with antibody or component.

Physiologic Limits of Health In implant dentistry, the range of function within which tissue can support an implant in health long-term. See *hypofunction*, *hyperfunction*, *overengineering*, *underengineering*.

Piezoelectric Effect 1. Electrical current generated by mechanical stress in certain crystalline materials such as quartz and bone; analogously, the converse property of expansion or contraction of these materials in response to an applied electric field. 2. In implant dentistry, the effect of such bioelectric current on the maintenance and remodeling of bone.

Pilot Drill The initial instrument used to establish angle of entry and depth of an implant osteotomy.

Plasma Spray A process involving deposition of metal powders that are totally or partially melted and then rapidly resolidify, forming a dense or porous coating.

Plastic Deformation Deformation, or strain, in response to mechanical force, or stress, in which the material does not return to its original shape and size when the applied force is removed.

Plate/Blade Form An endosteal implant, generally flat mesiodistally, parallel and/or tapered in cross section, that can heal and function in the osteointegration or osteopreservation mode of tissue integration.

Pluripotent Cell A cell able to develop along any one of a finite set of cell pathways to differentiate ultimately into a progenitor cell and then into a specific type of fully developed cell. Compare *progenitor cell*, *stem cell*.

Polyethylene (PE) Polymerized ethylene, $(CH_2-CH_2)_n$, a synthetic plastic material, forms of which have been used in reparative surgery.

Porosity 1. A condition of being porous. 2. A pore, passage, channel, or tiny opening. 3. The ratio, usually expressed as a percentage, of the volume of a material's pores to its total volume.

Positioning Stent A presurgical device that guides in the location and positioning of root form osteotomies.

Post-Core A post-retained tooth buildup, usually of metal, fitted within a prepared root canal when remaining tooth structure is insufficient for the retention of a planned prosthesis.

Posterior Palatine Foramina The inferior openings of the greater and lesser palatine canals, found bilaterally opposite the lingual root of the third molar on the horizontal plate of the palatine bone; transmits palatine nerves and arteries.

Press-Fit Implant Also *friction-fit implant*. 1. A root form that is pressed into position. 2. An endosteal implant whose initial retention is friction-dependent. Compare *threaded implant*.

Primary Intention Also *healing by first intention*. Healing in which union occurs contiguously without the intervention of granulation tissue.

Progenitor Cell An undifferentiated cell that has been programmed to proceed down a specific pathway to differentiate into a specific type of cell. Compare *pluripotent cell*, *stem cell*.

Progressive Loading The gradual increase in the application of functional force on a prosthesis.

Prospective Study A type of study or clinical trial in which methods, goals, and criteria for success and failure are clearly defined before the experimental protocol commences.

Proteoglycan Any of a group of polysaccharide-protein conjugates occurring primarily in the ground substance of connective tissue and cartilage, composed mainly of polysaccharide chains, particularly glycosaminoglycans, as well as minor protein components.

Rake Angle The angle between the rake face and the line connecting the edge to the axis of the bur.

Rake Face The surface of a blade in a bur that faces the direction of rotation to contact the structure being removed.

Ramping In implant dentistry, the removal of bone at the alveolar ridge crest, to increase width to enable insertion of an endosteal implant.

Ramus Frame Implant A mandibular endosteal implant consisting of a symphyseal plate/blade-like structure with a contiguous bar providing bilateral extension into the rami to support the prosthesis.

Randomization The characteristic of a study or clinical trial according to which subjects are blindly assigned to experimental and control groups regardless of expectations related to their prognosis to undergo the experimental treatment.

Regional Acceleratory Phenomenon (RAP) A local response in which tissues form 2 to 10 times more rapidly than the normal regeneration process. The process is more rapid in cortical than in cancellous bone.

Resorbable The property exhibited by substances that demonstrate a relatively high level of *in vivo* degradation. Compare *nonresorbable*.

Resorption The loss of substance through physiologic or pathologic means, such as loss of dentin and cementum of a tooth, or of the alveolar process of the mandible or maxilla.

Restorative Practitioner In the team approach, the practitioner who is responsible for the restoration of a dental implant case.

Retaining Screw 1. An attachment mechanism that joins an abutment or attachment/retention component to the implant body. 2. The attachment mechanism that joins a prosthesis to an implant abutment or attachment/retention component. 3. A screw used for initial retention of a subperiosteal implant against bone in early healing.

Retention The act or process of keeping in possession, or of holding in place or position (e.g., the resistance against forces of dislodgement exhibited by a prosthesis and its abutments). Compare *stability*.

Reticular Fibers Immature connective fiber tissues forming the reticular framework of lymphoid and myeloid tissue and occurring also in the interstitial tissue of glandular organs, the papillary layer of the skin, in association with the periosteum, periodontal and peri-implant ligaments, and elsewhere.

Retrospective Study A study in which the results of a number of similar cases already performed are reviewed. The cases can be related in terms of diagnosis, treatment plan, case presentation, longevity, or other criteria.

Ridge Expansion The mechanical widening of available bone to accommodate implant insertion or a grafting procedure.

Ridge Lapping 1. In prosthetic dentistry, the contouring of a pontic over a residual ridge to provide esthetics and the appearance of gingival emergence. 2. In implant dentistry, the contouring and positioning of the buccal/labial margin of a crown over an implant abutment in attached gingiva, to provide esthetics and the appearance of gingival emergence in conformity with adjacent teeth.

Root Form Also *cylinder, screw*. An endosteal implant, generally cylindrical in shape, parallel-sided or tapered, threaded or unthreaded, that functions in the osseointegration mode of tissue integration.

Rotational Speed The rate at which a bur or drill turns, expressed as the number of revolutions per unit of time.

Runout A measurement of the accuracy with which all the blade tips pass through a single point when a bur is rotated; it measures concentricity and the accuracy with which the center of rotation passes through the center of the head of the bur.

Safety Stop 1. In plate/blade form implant dentistry, the area at the base of the abutment that flares beyond the bucco/labio-lingual width of the osteotomy to prevent over-seating of the implant and impingement upon an anatomic landmark such as a nerve or sinus. 2. In the intramucosal insert treatment protocol, the round portion at the base of the cutting edges of the tissue receptor site and acrylic receptor site burs that prevents overpenetration.

Scoring In implant dentistry, the creation of an indentation on the ridge crest to record the position of a planned osteotomy directly upon the bone.

Scope of Treatment 1. The range of different types of cases that a practitioner can treat. 2. The range of different types of cases that can be treated using any given implant modality.

Screw Retention The use of a retaining screw (q.v.) for the retention of an abutment or prosthesis. Compare *cement retention*.

Semi-Submersion A healing protocol in which at the time of insertion an endosteal implant is fitted with a healing collar that remains flush with or up to 1 mm above the gingiva, allowing for afunctional healing to promote the osseointegrated mode of tissue integration. Compare *submersion*.

Serial Study A type of clinical trial in which a series of patients with similar treatment plans is evaluated over time.

Sharpey's Fibers 1. Collagenous fibers that pass from the periosteum and are embedded in the outer circumferential and interstitial lamellae of bone. 2. Terminal portions of principle fibers that insert into trabeculae of the cribriform plate associated with tooth roots or peri-implant ligaments. 3. Terminal portions of principle fibers of the periodontal ligament that insert into the cementum of a tooth.

Shear 1. An applied force that tends to cause opposite but parallel motion of contacting planes of an object. 2. The strain resulting from such force.

Sheath The network of collagenous fibers contiguous with the outer layer of the periosteum that envelops the struts of a subperiosteal implant in periosteal integration (q.v.).

Shock Absorption The dampening of applied force.

Shock Wave 1. A ridge or swell that moves across the surface of a body or liquid as a result of a disturbance. 2. A periodic motion or disturbance, consisting of a series of oscillations, that does not travel outward from the source but only vibrates as it passes.

Shoulder That portion of the body of a plate/blade form implant placed slightly apical to the ridge crest at insertion, from which the implant neck and attachment/retention component arises.

Shoulder Set-Point An indentation in the shoulder of a plate/blade form implant that facilitates insertion with a shoulder set-point seating instrument to control seating angle.

Sintering To transform into a solid mass of desired density or cause attachments between separate parts by heating without melting.

Sinus Lift Also *subantral augmentation*. Augmentation of the antral floor with autogenous bone and/or bone substitutes to accommodate dental implant insertion.

Sinusoid 1. Resembling a sinus. 2. See *sinusoidal capillary*.

Sinusoidal Capillary 1. An early manifestation of angiogenesis, as developing blood supply extends into areas of healing such as extraction sockets or implant osteotomies; such vessels immediately preceding and guiding earliest bone formation. 2. A form of terminal blood channel consisting of a large, irregular anastomosing vessel, having a lining of reticuloendothelium but little or no adventitia.

"Sleeper" A submerged root form implant that, because of an unfavorable location or insertion angle, cannot be used for support of a restoration and is left in position without function.

Sluiceway On an endodontic stabilizer implant, the groove at the crest of each tread, and the space between the central shaft of the stabilizer and the dentin lining the walls of the prepared root canal, that guides excess sealing cement coronally to prevent its expression into bone beyond the apex.

Solo Approach The performance of dental implant insertion and prosthodontic restoration by a single practitioner.

Solo Practitioner A practitioner who performs both the insertion and restoration phases of implant dentistry treatment.

Spiral Blade Angle The angle formed by the cutting edge of the blade and the long axis of the bur.

Sprouting In angiogenesis, the giving off of a shoot or bud by a vessel.

Stability 1. That quality of maintaining a constant character or position in the presence of forces that threaten to disturb it; the quality of being stable; to stand or endure. 2. Resistance to change. 3. The quality of a prosthesis to be firm, steady, or constant, to resist movement in response to functional horizontal or rotational stresses in the absence of dislodgement. Compare *retention*.

Static Equilibrium A condition in which the resultant of opposing forces is zero and no motion is present.

Stem Cell A cell of embryonic origin that is able to develop along any cell pathway to differentiate ultimately into a pluripotential cell, then a progenitor cell, and then into a specific type of fully developed cell.

Stent 1. A device used in conjunction with a surgical procedure to keep a graft in place. 2. See *positioning stent*.

Strain Change in length per unit length when tensile or compressive stress is applied; change in length divided by original length.

Stress 1. Force per unit area, which may cause strain (q.v.) on an object. 2. Forcibly exerted influence; pressure.

Stress Breaker A device built into a fixed or semi-fixed prosthesis, or a removable partial denture that relieves the abutment teeth from excessive torque loads and stresses.

Stress Transfer Homogenization The principle according to which the design of an implant promotes the equal transfer of stress at all points on its interface surfaces.

Strut 1. A structural component of a subperiosteal implant, positioned according to anatomic, mechanical, and/or prosthodontic dictates. 2. A portion of a subperiosteal implant that is placed against bone (i.e., main bearing strut [q.v.] or connecting strut [q.v.]) or protrudes through the gingiva to act as an abutment (pergingival strut [q.v.]).

Submersion A healing protocol in which an endosteal implant is placed within bone and covered with gingiva, with no portion protruding, allowing for afunctional healing to promote the osteointegrated mode of tissue integration. Compare *semi-submersion*.

Subperiosteal Implant Also *eposteal implant*. An implant that is placed beneath the periosteum and overlying the bony cortex at the time of insertion, to be sheathed ultimately by dense fibrous connective tissue contiguous with the outer layer of the periosteum to function in the periosteal mode of tissue integration.

Substrate A material upon which a different material is deposited or adhered, usually in a coating or layer.

Success Criteria Conditions established by a study protocol for the evaluation of a procedure as a success.

Success Rate The percentage of successes in a study or clinical trial according to success criteria (q.v.) defined by the study protocol. Compare *survival rate*.

Surface Pit A hole or cavity in a material or tissue; a tiny depression.

Survival Rate The percentage of survivals in a study or clinical trial in implant dentistry, defined as devices that are in position and functioning for their intended purpose at the time of evaluation. Compare *success rate*.

System A specific product line of implants. Compare *modality, configuration*.

Taper Angle A degree of angular variation from vertical that quantifies the taper.

Team Approach In implant dentistry, treatment of a case by two practitioners: an insertion practitioner (q.v.) and a restorative practitioner (q.v.).

Tension The act or condition of being stretched or strained; the degree to which anything is stretched or strained.

Threadformer Also *tap*. A device used in the insertion protocol of a threaded root form to thread the walls of the osteotomy before implant insertion.

Ti6AL4V A biocompatible metallic alloy composed of 90 parts titanium, 6 parts aluminum, 4 parts vanadium, and trace amounts of other elements, used for the fabrication of dental implants and their components.

Tissue Reflection In implant dentistry, the elevation and folding back of soft tissues to expose bone.

Tissue-Tac On some plate/blade form implants, a stable interface texture that is impressed into the surface at the time of coining to increase surface area and retention.

Titanium A dark-gray, biocompatible metallic element of widespread distribution but occurring in small amounts; atomic No. 22, atomic weight 47.90, symbol Ti, specific gravity 4.5, density 4.5 gm/cm³, modulus of elasticity 105,200 N/mm². In implant dentistry, supplied as commercially pure (CP, ASTM F67, classified in four grades) or in a variety of alloys.

Toxicity 1. The capacity of a foreign substance to cause adverse reactions in tissues at the local or systemic level. 2. The quality of being poisonous, especially the degree of virulence of a toxic microbe or of a poison.

Trabeculae Anastomosing bony spicules in cancellous bone that form a meshwork of intercommunicating spaces.

Transfer Coping A component that fastens to an inserted implant body to record its position for the placement of its coordinated analogue in a master model.

Transfer Coping Attachment Screw A screw that fastens a coordinated transfer coping to an inserted implant body.

Transmucosal Passing through the gingiva or oral mucosa.

Transosteal Implant Also *mandibular staple implant, transmandibular implant*. 1. A dental implant that completely passes through the alveolar ridge bucco/labio-lingually. 2. A dental implant that completely passes through the parasymphiseal region of the mandible, from the inferior border through the alveolar crest.

Trial Fit Gauge Also *implant try-in*. A replica or near-replica of the body of an implant configuration used for testing the size of a prepared osteotomy.

Tru-Grip Body In some plate/blade form implants, the stepped design of the body that increases interface area and promotes primary retention.

Tuberosity The rounded distal eminence of the alveolar ridge at the posteroinferior angle of the infratemporal surface of the maxilla.

Twist Drill In certain root form osteotomy preparation protocols, a drill used to widen a preliminary osteotomy.

Two-Stage Implant An implant not equipped with its attachment/retention mechanism at the time of insertion.

Underengineering Insufficient abutment support in endosteal implant dentistry. Underengineering can result in overstimulation of the tissues supporting the implants and consequent bone loss resulting from hyperfunction. Compare *overengineering*.

van der Waals Forces Also *hydrophobic bonding*. The relatively weak, short-range forces of attraction between atoms and molecules that result in the attraction of nonpolar organic compounds to each other.

Vent An opening in the body of an endosteal implant that allows for tissue ingrowth for increased retention and stability.

Viscoelastic Both viscous and elastic. In a time/temperature related environment, stored energy may be dissipated in a viscoelastic substance.

Vitallium, Surgical Also *chrome-cobalt alloy*. Trade name for a biocompatible cobalt-chromium-molybdenum alloy often used for the casting of subperiosteal implants.

Width The buccal/labial-lingual dimension of an implant or available bone. In root forms, the major diameter of the implant.

Wolff's Law A bone, normal or abnormal, develops the structure most suited to resist the forces acting on it.

Woven Bone Also *nonlamellated bone, primitive bone*. Bony tissue found in the embryo, young children, early healing, and in various pathologic conditions, in which the bone fails to show the oriented arrangement of collagen fibers characteristic of lamellated bone.

Xenogenic Graft Also *xenograft, heterograft, heterologous graft*. Grafting material harvested from a species different from that of the recipient.

Xenograft See *xenogenic graft*.

Yield Strength The amount of deforming force, or stress, just above the elastic limit, at which point a substance begins to exhibit plastic deformation (q.v.).

Zygomatic Arch The arch formed by the articulation of the temporal process of the zygomatic bone and the zygomatic process of the temporal bone.

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